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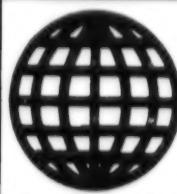
JPRS Report

Science &
Technology

Central Eurasia:
Engineering & Equipment

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Multicriterial Optimization of the Technological Feasibility Indicators of an Aircraft Engine's Design During Development of Its Technological-Design Characteristics

[Article by G.I. Balayev, candidate of technical sciences, Defectology Scientific Research Institute (NIID), Moscow, and V.V. Kuzmin, doctor of technical sciences, Mosstankin [not further identified]; UDC 621.453/457.001.76:681.5]

[Abstract] The authors of this article have examined a method of multicriterial optimization of the technological feasibility indicators of an aircraft engine's design in the stage where its design and technological characteristics are being developed. The essence of their approach is as follows. The informational attributes characterizing a given design are subdivided into attributes of a design profile and of a technological profile. The category of features related to an engine's design is further broken down into the geometric distinctions of components (shape, overall dimensions, mass, complexity of configuration, precision of dimensions, roughness of individual surfaces), working parameters (life, power and traction, efficiency, and reliability), and physicochemical properties of the engine's materials (workability, ultimate strength and yield point, hardness, density, impact strength, and number of grades). The category of technological features of an engine's design is broken down into efficiency criteria (production cost, labor intensity, specific metal consumption, level of standardization and cooperation, energy intensity, shape of the blank, and capital costs) and engineering and organizational support (structure of the preparation area and equipment required, automation and mechanization, manufacturing process flexibility, and production program). Next, the global task of multivariational analysis and multicriterial optimization of an engine's design and technological characteristics is broken down into the multiply connected local tasks of determining the following: manufacturability, reparability, technological preparation of production, reliability, working parameters, and alternative design versions of the same engine. Equations are provided for use in executing the multicriterial optimization procedure described. Tabular data reflecting calculations made during the multicriterial optimization of 11 different engines (not mentioned by name) are presented. The said calculations demonstrate that alternative versions of optimal technological and design decisions are possible and that trade-offs in the form of slight sacrifices in one evaluation criteria may result in significant gains in others. Figures 2, table 1; references 4 (Russian).

The Laminar-Turbulent Transition of a Boundary Layer Beyond an Irregularity on the Attachment Line of a Gliding Cylinder in a Supersonic Flow

[Article by A.S. Skuratov and A.V. Fedorov, Moscow; UDC 532.526.3.011]

[Abstract] The authors of this study conducted an experimental investigation of the effect of a single two-dimensional irregularity and sand turbulizer on the laminar-to-turbulent transition of a bounder layer in the case of supersonic circulation around a gliding cylinder. The experiments were conducted in a wind tunnel with a working section measuring 150 mm and an oncoming-flow Mach number of M_∞. The unit Reynolds number ($Re_{\infty,1}$ was varied within the range from 0.38 to -4.58 x $10^7 m^{-1}$ by varying the pressure in the forechamber. The mean-square pressure pulse in the nucleus of the flow caused by the noise of the turbulent boundary layer on the pipe walls amounted to $p_{rms}/p_e \approx 2$ to 2.5%, which corresponds to the standard background level of units of the said class. The cylinder's surface roughness was less than $R_z = 4$ μm. A model with a diameter of 15 and 20 mm with a glide angle of $\chi = 45$ and 60° was used. The length of the models was between 150 and 205 mm depending on the angle χ. Each model was fashioned in two versions: smooth and with a controlled irregularity. The irregularity was in the form of a steel wafer 0.2 mm long in the direction $y = 2$ mm and was located in the center of the cylinder's spread ($x = 0$). In the concluding series of experiments a turbulizer in the form of four rows of grains of scouring powder with an average diameter of 0.3 mm was attached to the models. The state of the boundary layer around the leading edge of the cylinders was determined based on the distribution of the heat flux to the circulated surface along the attachment line, which was in turn measured by the method of heat-indicating coatings. The error in measuring the heat flux amounted to about 8% in the case of a smooth wafer and could have been somewhat higher in the case of a curvilinear surface. Heat indicators with melting temperatures in the range from 348 to 433 K were used. Shadow photographs were also taken. The studies performed indicated that just two local parameters, namely, k and R^* (the height of the irregularity and the Reynolds number, respectively), were criteria indicating a change in the characteristic modes. Both k and R^* were found to be weakly dependent on the unit Reynolds number or (in other words) on the level of the acoustic background in the oncoming flow. In a diagram of the points obtained in experiments on smooth models with an irregularity, the points grouped along rays in the plane k, R^*. Three lines of points marking changes in the laminar-turbulent transition that were directly linked to the size of k and R^* were evident. In the region of high values of k and R^*, a transcritical mode developed as soon as line I was crossed. Then, as k and R^* increase, the

transition front moves closer to the irregularity. After a second point on the said diagram (designated line II) is crossed, an effective regimen is established during which turbulence occurs directly behind the irregularity and remains in existence along the entire length of the cylinder's attachment line. At yet larger values of k, where the nature of the laminar-turbulent transition changes qualitatively. A third line in the diagram (designated line III) marks the transition between a subcritical mode and a mode of degenerating turbulence. The study findings were found to be in good agreement with the previously published findings. Figures 5; references 10: 7 Russian, 3 Western.

An Investigation of SCh-2 Satellite Navigation Apparatus

[Article by Yu.G. Firsov; UDC 629.783:527.6:528]

[Abstract] The series production of the SCh-2 satellite navigation apparatus marks the beginning of the end of the Soviet lag in the field of the use of first-generation civilian-use satellite radio navigation systems. The SCh-2 satellite navigation apparatus is designed to determine the coordinates of a ship's location based on radio signals from the Tranzit and Tsıkada satellite radio navigation systems. Based on the results of a session of communication with low-flying navigation earth satellites, the SCh-2 satellite navigation apparatus can perform the following navigation and auxiliary tasks: calculate routes based on course and velocity data obtained from onboard sensors or input manually; correct coordinates (either automatically or manually), determine and give consideration (also automatically or manually) to the direction and rate of total drift based on data from two sequential quality communication sessions with one of the aforesaid satellite radio navigation systems, perform specified navigation tasks repeatedly with increasingly more refined input data, and display data on a display device and document it on tape. From the standpoint of its software, the SCh-2 satellite navigation apparatus is on a par with its most advanced world counterparts (including the MX-1102 and MX-1107). Especially noteworthy among the features of the software developed for the SCh-2 satellite navigation apparatus are its capability to accomplish the following: give consideration to vessel course velocity errors when performing navigation tasks, store tables of geoid corrections in a ROM unit, implement software tracking of low-flying navigation earth satellites and select the best session with consideration of forecast data, store satellite forecast data regarding all low-flying navigation earth satellites in a long-term storage with a separate power source, conduct periodic automatic testing that does not interrupt the operation of the SCh-2, recalculate position data and recalculate it for any specified ellipsoid, maintain "watch" and "one-time observation" modes, and issue any required warning signals. The SCh-2 satellite navigation apparatus may be interfaced with the OEL-2 and IEL-2M relative logs and the Onega absolute Doppler sonar log. The SCh-2 satellite navigation apparatus was subjected to controlled tests to assess its ability to track a ship's movements based on data received from the Tranzit and Tsikada navigation satellites. According to an analysis of a series of 15 simultaneous ship locations by the SCh-2 and the MX-4400 obtained on identical courses under similar hydrometeorological conditions and assuming a data input error of 0, the error of the readings of output by the SCh-2 equaled M = 387 m. At the same time, however, the software of the SCh-2 was demonstrated to have obvious advantages over that of the MX-4400. After processing the results of 188 qualitative determinations of ships' locations based on the Tranzit system and 133 determinations based on the Tsikada system, the researchers concluded that the precision of the said locations was twice as high in the first case. Despite the overall high performance of the software developed for the SCh-2, isolated soft failures did occur during the tests. The following service functions were also shown to be needed and recommended for development in the future: a code to input the time zone so that data could be displayed and recorded based on ship time; recording of the parameters of the vessel's total drift so that both previously recorded and present values would be available; and display of the gyrocompass course to permit tracking to a specified point when specifying the mode of sailing along a route. Tables 2; references 6 (Russian).

An Investigation of the Circulation of Bodies of Revolution With a Riabouchinsky Generatrix

[Article by V.V. Vyshinskiy and Ye.N. Kuznetsov, Central Aerohydrodynamic Institute imeni N.Ye. Zhukovskiy, Zhukovskiy, Moscow Oblast; UDC 629.76.015.3]

[Abstract] When a body of revolution of a specified length and volume is circulated, the critical Mach number reaches its maximum value when the body is formed by two coaxial disks placed crosswise to the oncoming gas flow and connected by the surface of a current along whose every point the speed of sound is reached. This axisymmetric case of bodies that are optimal from the standpoint of critical Mach number has been investigated elsewhere. The analogue of this type of flow in an incompressible fluid is what has been termed a Riabouchinsky flow, in which the area of constant pressure behind a disk placed crosswise to a flow is closed by a "reflected" disk that is symmetrical relative to the plane of the midsection of the cavern. The authors of this study examined the circulation of bodies of revolution with a Riabouchinsky generatrix. Studies were performed on the ADT-112 wind tunnel at the Central Aerohydrodynamic Institute imeni N.Ye. Zhukovskiy in order to derive the aerodynamic characteristics of optimal nose sections. In the experiments a nose

section with an elongation of $\lambda = 0.87$ was connected to a cylinder with an overall elongation of $\Lambda = 3.5$. The diameter of the middle of the nose section was 0.1 m, and the cross section of the working area of the wind tunnel measured 0.6 m x 0.6 m. The nose sections were mounted on mechanical balances with a tail holder. Methodological corrections and corrections for the bottom pressure, which was measured simultaneously with the weight experiment, were made to the values obtained for the aerodynamic characteristics. The point at which the laminar boundary layer became a turbulent layer was located close to the body's nose. The aerodynamic characteristics were measured with a precision of +/-0.1% of the maximum load in the given measurement range. The mean square deviation of the Mach number from the specified value amounted to 0.001. It was discovered that a nose section with a Riabouchinsky generatrix and with flat blunting possesses optimal aerodynamic characteristics in the range of oncoming-flow Mach numbers $M_* < M_\infty < 0.97$ at attack angles of $0 \leq \alpha \leq 10°$. Figures 4; references 8: 6 Russian, 2 Western.

Damping Self-Sustained Rotor Vibrations

[Article by V.I. Antipov, Nizhniy Novgorod; UDC 624.07:534.1]

[Abstract] The author of this study has examined the problem of stabilizing a dynamically unstable rotor system by using induced vibrations due to unbalance. The study object was a rigid rotor turning at a constant angular velocity ω around a symmetry elastic base. The nonlinear properties of the elastic base were assumed to be identical in two mutually perpendicular directions and described by piecewise-linear characteristics. It was assumed that the cantilever portion of the rotor was subjected to the effect of some external medium (fluid). It was further assumed that the rotor's forced vibrations due to unbalance were realized in the form of a forward synchronous precession. The harmonic balance method was used to find a stationary periodic vibration mode. The stability of the stationary vibration mode was investigated by using first-approximation equations. The calculations performed confirmed that it is, in principle, possible to stabilize a rotor system such as the one studied by using a forced vibration regimen. The said regimen may be used in actual practice to damp self-sustained vibrations. Figures 3; references 9 (Russian).

The "Vortex-Grid" Method for Computing Laminar and Turbulent Flows of a Viscous Incompressible Liquid

[Article by P.A. Baranov, V.V. Gliznutsa, M.I. Nisht, and A.G. Sudakov, Feodosiya Affiliate, Parachute Making Scientific Research Institute; UDC 533.6.013.42]

[Abstract] The discrete vortex method is currently widely used to calculate nonviscous flows. Despite its many advantages, it is not well suited for use with processes of diffusion and turbulent transfer, both of which are characteristic of many types of flows that are very important from a practical standpoint. In view of this fact, the authors of this article have proposed a numerical method of solving non-steady-state two-dimensional Navier-Stokes or Reynolds equations written in the form of vorticity transfer equations. The new method is essentially a development of the discrete vortex method applied to flows of a viscous incompressible liquid. The main assumptions underlying the proposed approach are as follows: 1) the principle of splitting the starting differential equation by physical processes is used (i.e., into equations of vorticity generation and diffusion processes and the process of convective transfer); 2) a combined Euler-Lagrange approach is used in which diffusion of vorticity is calculated on a difference grid adapted to the form of a circulated body; 3) the integral form of writing boundary conditions is used for vorticity, which makes it possible to strictly adhere to the principle of conservation of total vorticity; and 4) a two-parameter k-ε model of turbulence is used when calculating turbulent flows for closure of the Reynolds equations. A Poisson equation for the current function is solved to calculate the velocity field in the proposed method. The known grid values of the current function are used as a basis for determining the components of the velocity vector at the nodes of the grid. The velocity at an arbitrary point is found by interpolation. This approach provides a significant gain in speed as opposed to when the Biot-Savart law is used. The use of the new method is illustrated by way of the example of a computation of the circulation of a thin plane disk given different flow regimens. The following three cases are examined: 1) the dependence of the coefficient of resistance of the disk on the Reynolds number determined by the disk diameter and velocity of the oncoming flow in the case of laminar circulation; 2) turbulent circulation of the disk; and 3) the dependence of the disk's coefficient of resistance on time for initial Reynolds numbers (Re_0) of 50, 100, and 10^8 and for dimensionless accelerations (W) of 0.1 and 0.5. The calculations performed showed that the viscosity of the medium was significantly dependent on the disk's coefficient of resistance only at rather low values of W and Re_0 (W < 0.1 and Re_0 < 50). At initial Reynolds numbers greater than 100 and accelerations greater than 0.5, it is entirely valid to study such modes of motion within the framework of the model of an ideal medium. Figures 3; references 8 (Russian).

Calculating the Parameters of a Detached Flow Behind a Plane Rounded Body Circulated by Two Supersonic Flows

[Article by V.K. Masalov and R.K. Tagirov, Moscow; UDC 532.526.5]

[Abstract] A method has been developed for calculating
the bottom pressure and coordinates of the separation
points on the curvilinear surface of the trailing edge of a
plane body circulated by two supersonic flows. The new
method gives consideration to local overexpansion of the
flows. The new method is based on the following basic
assumptions: the bottom pressure is constant, the initial
boundary layers are thin and have a negligible effect on
the mixing zone, the flows are circulating curvilinear
surfaces in accordance with a Prandtl-Meyer solution,
and the separation points are located where the critical
pressure differential on the shockwave is reached (i.e.,
$P_g/P_s = P_{cr}$). To check the validity of their proposed
method, the authors compared their calculated data with
experimental data published elsewhere. Calculations
were performed for three versions of the conditions
determining a separation point. In the first version, it
was assumed that the separation of the turbulent
boundary layer arises at the point where $p_g/p_s = P_{cr}$. In
the second version, it was assumed that the separation
occurs at the point where the pressure equals the bottom
pressure. In the third version, it was assumed that a
sharp expansion of the flow along the surface of the circle
results in laminarization of the boundary layer and that
the separation point is determined by the equality $p_g/p_s
= P_{cr\,1}$, where $P_{cr\,1}$ corresponds to a laminar mode.
Analysis of the results obtained shows that the magni-
tudes of the bottom pressure for all three versions
virtually coincide with one another and with experimen-
tally obtained data published elsewhere. In the third
version, good agreement was also achieved with the
experimental data with respect to the level of the pres-
sure drop before the separation and at the location of the
separation points on the surface of the circle. The pattern
of a graph plotted on the basis of the calculated results
was also found to be in good agreement with published
shadow photographs of the circulation of a semicircular
recess. Figures 2, tables 3; references 4: 1 Russian, 3
Western.

Protecting Conic Bodies From Vibration and Shocks

[Article by A.V. Shulzhenko and M.A. Pavlovskiy, Kiev;
UDC 531.383:534.1]

[Abstract] The authors of this study examined the spatial
position of conical and close-to-conical bodies and pro-
tecting them against vibration and shocks when sub-
jected to the effect of rigid dynamic factors. Specifically,
they examined a method for constructing equations of
the three-dimensional motion of conical bodies whose
bearing structure is subjected to the effect of multihar-
monic vibrations. During the course of their mathemat-
ical analysis of the problem, the authors developed
stability criteria for the nonexcited state of a body of the
said type in an original elastically damping suspension
that includes three shock-absorbing elements. They then
proceeded to assess methods of increasing stability by
giving consideration to rigidity and damping character-
istics. The computation results indicated that designing
the suspension so that the first and third of the three
shock-absorbing elements have different degrees of stiff-
ness helps to automatically increase rigidity and
damping when the amplitudes of the vibrations increase
and thereby increase the extent of the shock absorbers'
vibrations, which in turn facilitates tuning out-
of-resonance modes. The results of the studies per-
formed have been used in developing, researching, and
optimizing the mechanical portion of the indicator of a
ship-based detection and ranging system. Figures 5;
references 11 (Russian).

A High-Sensitivity Telescope-Interferometer With Point Scanning of Objects

[Article by V.G. Zakin and Ye.I. Tolkova, Gorkiy State University; UDC 535.411]

[Abstract] A new high-sensitivity telescope-interferometer with point scanning of objects has been developed. The new instrument, which is actually called a Michelson telescope-interferometer because it is designed to construct the image of an object rather than its spectrum, is based on the principle of image construction by means of the method of partially coherent holography. The optical portion of the new Michelson telescope-interferometer includes a modified Michelson interferometer with electronic modulation of the lengths of the arms and lens that constructs a reduced image of the interference pattern in the pupil of a single photoreceiver. The detector thus transmits the instantaneous output power of the radiation rather than the details of an interferogram. This explains the improved sensitivity of the Michelson telescope-interferometer in the observation of low-contrast objects. Unlike a conventional telescope or interferometer, the new Michelson telescope-interferometer is not plagued with frequency distortions during recording. The Michelson telescope-interferometer retains the characteristics of a modified Michelson interferometer (the same unit transfer function, an acceptable wavelength spectrum width, the same effect of plane focusing, etc.). At any given moment in time, the Michelson telescope-interferometer constructs the image of just one point of an object. The level of the signal in the Michelson telescope-interferometer's photoreceiver is proportional to the total received power, whereas the level of the signal when an interferogram is recorded is proportional only to that power that is received at one of K x K readout points. The noise level of the photoreceiver at the output of the Michelson telescope-interferometer is thus K-fold less than that in the case of a conventional interferometer. In the case of low-contrast objects, the improvement in the signal-to-noise ratio of the new Michelson telescope-interferometer over a conventional interferometer is quite significant (an order of magnitude). The new Michelson telescope-interferometer constructs an ideal image free of any distortions except for diffraction clipping of the frequency band. The Michelson telescope-interferometer may be used to observe a specified point in space as well as to construct the image of weakly illuminated objects that do not lend themselves to artificial illumination. Figure 1; references 5: 4 Russian, 1 Western.

The Effect of Irradiation on the Optical and Dielectric Properties of X/65/35 PLZT Ceramic

[Article by H. Weber, G.Zh. Grinvalds, S.S. Dindun, Kh. Klima, A.A. Kruminya, A.N. Rubulis, A.A. Sprogis, U.A. Ulmanis, Kh. Shvabl, and A.R. Sternberg; UDC 537.226.4:539.16.043]

[Abstract] The authors of this study examined the effects of irradiation on the optical and dielectric properties of X/65/35 PLZT (lead, lanthanum, zirconium, titanium) ceramic (X = 4.5 to 10.5 at.% La). The specimens were manufactured from a chemically coprecipitated starting material by the technique of two-stage hot pressing. The parameters of the crystalline lattice and phase composition of the study specimens were controlled by a DRON-2 x-ray diffractometer, and neutron activation analysis was used to determine their stoichiometry. Specimens measuring 10 x 10 x 0.2 mm with optically polished surfaces were used to create a uniform distribution of defects during irradiation. Specimens measuring 5 x 5 x 1 mm^3 were used for the dielectric measurements. Three different radiation sources were used: 1) a research reactor producing radiation with an average power of 1.15 MeV, dose rate of 1,050 rad/s, and dose up to 6 x 10^8 rad was used (during the irradiation the specimens had a temperature of 45 to 60°C); 2) a linear accelerator was used to produce an electron energy of about 4.5 MeV, flux density of $10^{12}/cm^2$ x s, and dose up to 4 x $10^7/cm^2$; 3) a TRIGA MARK II reactor was used to irradiate test specimens with neutrons and γ-quanta at a neutron flux density of 2.1 x 10^{13} (total) and 7.6 x $10^{12}/cm^2$ x s at a dose up to $10^{18}/cm^2$ and at a γ-quantum dose rate of 2.7 x 10^4 rad/s (during which the specimen temperature did not exceed 60°C). After irradiation, all of the PLZT specimens acquired a yellow coloration indicating the appearance of additional absorption in the ultraviolet region of the spectrum. This observation was confirmed by spectral measurements. A sharply expressed maximum at a wavelength of about 380 nm was observed in the spectrum of the difference in optical absorption for all of the irradiated specimens. This maximum was the same regardless of whether the individual specimens had been irradiated with neutrons, electrons, or γ-quanta. This finding led the researchers to hypothesize that only one type of defect that can be created by all three types of irradiation participates in the change in optical properties experienced by the PLZT ceramic specimens upon irradiation. The most significant change in optical properties occurred after neutron irradiation. Annealing temperatures also turned out to be different for the different types of irradiation. In the case of specimens irradiated by neutrons, annealing processes were found to begin at room temperature, whereas in specimens irradiated with electrons and γ-quanta, annealing began at temperatures of about

110 and 140°C, respectively. Neutron- and electron-irradiated specimens regained their initial optical properties at temperatures of 400 to 500°C, whereas the difference in absorption in the case of the γ-irradiated and control specimens reached a level below the experimental resolution by a temperature of about 300°C. Irradiation by reactor neutrons was also found to induce significant changes in the shape and size of the test specimens' dielectric hysteresis loops. This was especially true in specimens with a low lanthanum content. An interesting correlation between changes in optical and dielectric properties was found. It was especially apparent in the case of materials with a close-to-cubic structure (X > 9 at.% La). Figures 4; references 10: 3 Russian, 7 Western.

Universal Towed Vessel for Acoustic Research

[Article by N.N. Dmitrevskiy, V.N. Kuznetsov, A.V. Kulikov, A.V. Nosov, and T.G. Kharatishvili, Oceanology Institute imeni P.P. Shirshov; UDC 551.46.082:534]

[Abstract] The new UBN universal towed vessel [UBN being an acronym for the words "universal towed vessel"] was produced during the course of a project to create a multibeam towed sonar unit that has been underway for a number of years in the Laboratory of Scattering and Reflection of Sound in the Ocean of the Oceanology Institute of the USSR Academy of Sciences. The UBN universal towed vessel was developed and produced by the laboratory in a joint effort with the All-Union Scientific-Research Institute of Physicotechnical and Radio Engineering Measurements [VNIIFTRI] of the USSR State Committee for Standards [Gosstandart]. The UBN is intended to carry the receiving and transmitting sonar equipment required to simultaneously study the angle and three-dimensional characteristics of the scattering of sound along the bottom of the ocean in a vertical plane parallel to the towing direction. The general principle of the said systems' operation has been detailed elsewhere but is essentially based on the use of two linear antennas (receiving and transmitting) mounted on board the vessel perpendicular to one another. This antenna configuration makes it possible to analyze the characteristics of scattered acoustic fields in the region where their directional patterns intersect. The UBN universal towed vessel may also be used to hold other sonar and oceanological equipment, including high-power low-frequency radiators, acoustic depth finder-profilographs, magnetometers, etc. From a design standpoint, the UBN is a towed body connected to an on-board set by a KG-7 seven-core cable line 2,000 m long. The towed body consists of a frame hull covered by fairings. It is equipped with advanced horizontal and vertical stabilizing planes, a turning descent wing with a Clerk-Y profile and an area of 0.6 m^2, a rectangular elongated radiator in the form of a lift airfoil, and a rigid 33-element linear antenna. Five cylindrical pressure hulls (diameter, 160 mm) based on Potok series-produced current meters are mounted under the fairings. Each of the hulls is equipped with an identical pressure-seal connector that was developed at the VNIIFTRI. The receiving sonar antenna is a linear equidistant antenna made of spherical hydrophones 30 mm in diameter that are spaced at a distance of 120 mm. Each hydrophone is equipped with a built-in preamplifier. The emitting sonar antenna is made of spherical piezoelectric elements 50 mm in diameter. It consists of three identical rectangular sections of 84 elements each. All of the piezoceramic elements in the antennas have been made in the form of individual modules with standard pressure-seal leads to make the system easier to modify in the future. The vessel measures 3,500 x 5,000 mm and weighs about 600 kg. It has a working towing speed of 3 to 6 knots and a limit submersion depth of 2,000 m. Tests of the UBN universal towed vessel conducted during the fifth expedition of the scientific research vessel Akademik Sergey Vavilov in the Atlantic Ocean confirmed the soundness of the engineering decisions made when it was designed. It remains highly stable when towed and is a promising tool for studying the characteristics of sonar signals scattered along the ocean floor. Figures 4; references 3 (Russian).

Nuclear Testing in Kazakhstan Outside Test Site

[Article by Yuriy Lushin: "A Big Secret 'For Peaceful Purposes'"]

[Text] This is by no means the end of the story because the secrets that I touched on are too deep. And it started by chance.

It came to me about 3 years ago on an expedition with biologists who were counting the numbers of saiga antelopes. The work was tedious: Fly in a tiny AN-2 aircraft for 8 hours a day searching from the air and counting the herds of the steppe antelope that by some miracle are still living even in our days (from the results of the count the scientists offer recommendations on the numbers of saiga that can be shot without harming its reproduction). We flew above the steppe in squares, going from Aktyubinsk Oblast first to the edge of Guryev Oblast a..d then to the edge of Uralsk Oblast (the saiga know no frontiers). On some days the flights were suddenly cancelled even though it was beautiful May weather, and the pilot was fit, and the aircraft was in proper order.

"Circumstances," Eldos Ismagilov, the leader of our expedition would sigh mysteriously. The burden of some secret was weighing down on him, but he was not able to live with it for long. "This test site is shutting off our oxygen," he would say. "They are firing again and we are banned." Even though they stopped their experiments during the time that the saiga were migrating...

A day later the missile people would allow us to fly. Of course, the test site was empty; the saiga had left only a chain of tracks on the damp earth by the water holes. Everything living had hastened to remove itself from this accursed place, and all we saw was an occasional pair or threesome of animals that had been left behind. Were they sick? Wounded? It is hard to say. Eldos pointed out an almost unnoticed place between the sand hills and said that for some reason the film in the cameras was being exposed, and so there was no reason to delay. The local hunters also knew about it, but no one could explain the reason for the strange phenomenon. On another occasion, now back on the ground, they showed me an enormously deep crater of unknown origin. I stood on its lip, and everyone put forward his own hypothesis.

"It was a meteorite strike."

"It is a karst sinkhole" (So why were there no other in the vicinity?)

"Perhaps a nuclear explosion?" I suggested, but no one supported that version. At the time it seemed fantastic. Nevertheless, I did designate the suspicious place with a question mark on a map of Kazakhstan. The mark was made in Bayganinsiy Rayon in Aktyubinsk Oblast. How could I foretell that this point would become the start of a map of nuclear explosions that were carried out not just at the Semipalatinsk test site? It turned out that they were conducted in various oblasts of Kazakhstan starting from 1966 (and perhaps even earlier?) right up to recent times.

When I was already in possession of documents confirming the reality of dozens of atomic explosions outside the test site I went to former Politburo member D.A. Kunayev, with a question: Did Dinmukh, imed Akhmedovich know anything about this?

"No, it is the first time I have heard of it."

"And this despite the fact that you were on friendly relations with Brezhnev himself?"

"Nevertheless, I know nothing. I knew little about the Semipalatinsk test site. Everything was under the power of the military, and they did not share their secrets with us."

Perhaps, of course, we might be surprised at the extreme lack of curiosity of the erstwhile leader of the republic. Perhaps we may doubt the veracity of his admission. But I believe that he really was ignorant about this.

But let us return to my nuclear investigation. It moved slowly. The second point on the map appeared on a year later. It was at Mangyshlak at the time when they started to talk about conversion and the top secret Caspian mining-and-metallurgical combine (PGMK) in the city of Shevchenko opened its doors for the first time to journalists. I visited a quarry where they mined uranium ore. They assured me that it was quite safe to work there. But for some reason all the dump truck drivers traveled in respirators and the roads were being constantly flooded (Later the director of the Kazakh Soviet Socialist Republic [SSR] Academy of Sciences Institute of High Energy Physics, I.Ya. Chasnikov, enlightened me and explained that the ingress of radioactive dust particles even as small as a micron into the lungs can lead to the formation of malignant tumors. But of course, there was no danger). It was there at Shevchenko that I heard about a certain drilling master who 20 years before had taken part in the drilling of an unusual bore hole a meter in diameter in Yeraliyevskiy Rayon. It was not a deep hole, about half a kilometer. When they had finished, the bore hole was taken under the control of the military, enormous coils of cable and boxes containing instruments were brought in, and a guard was posted.

Infected by this time with the Semipalatinsk test site syndrome, I compared the facts. Bore holes a meter in diameter were also bored for atomic explosions at the test site, and to the same depth, and along with the bomb cables attached to instruments were lowered into the ground to record the parameters of the detonation. Similar, very similar... But to what end had they torn Mangyshlak apart? Those who had taken part in the experiment could tell, if they were willing. Where to find them? At that time I did not know that the military had selected a site for yet another nuclear test site, and that on Mangyshlak, 100 kilometers from the small town of

Say-Utes, during 1969-1970 not one but three atomic explosions took place at depths of 410 to 740 meters. But something there did not suit the military. Was it perhaps that enormous subsiding craters appeared at the epicenter of the explosion, like those at the Nevada test site? At Semipalatinsk that did not happen; there the ground was simply burst asunder and fissures were formed that could be hidden by pressing them flat with bulldozers. But here the atomic secrets were too obvious.

I suggested that the Mangyshlak experimenters would most likely be in Kurchatov, on the test site. It was understood that they would hardly be found so simply, nevertheless it was worth a try. A second journey to the test site along with activists from the Nevada-Semipalatinsk movement could not be put off. I was aware that it would be necessary to meet with the leadership of the test site but I understood that none of the generals would answer my question (especially after the piece I had published about the test site). How to ask it? Try circumlocution, walk round the target dropping hints? There was too little time. So I decided that come what may, given any convenient chance I would ask my question directly of any of the physicists or specialist officers. The chance presented itself and I asked a colonel (I shall not disclose his name or duties).

"I know," I said as confidently as I could, "that your people conducted tests not only at the test site but also in various oblasts in Kazakhstan, as, for example, Aktyubinsk and Mangyshlak."

"And in Guryev and Uralsk oblasts also," my interlocutor unexpectedly added, "but that was not our work, it was the Ministry of Atomic Energy and Industry."

"When was that?"

"In various years, I cannot say for sure."

"And the rayons, you do not know?"

"It was of no interest to me." The colonel was beginning to get annoyed. But I had been lucky so I decided to check one more unlikely rumor.

"Tell me, is it true that there was a case in which a hydrogen bomb was lost on the test site?"

"Utter nonsense. Some illiterate Kazakh shepherd found a cylinder on the steppe marked 'Hydrogen' and raised a panic."

Also interesting—illiterate but he could read. Amantay Kaliyev, the leader of the Nevada movement in Pavlodar told me about this case another way. By the way, a large part of the test site is located right there in Pavlodar Oblast, so that it might even be called the Pavlodar site.

"The affair happened in 1967," Amantay related. "A herder, one Botay Kaishbayev, was taking horses to Mayskiy Rayon in our oblast, and near the nomad camp at Beketay he stumbled across a strange object that was obviously of military origin. The herder was scared and

he raised a fuss. The military arrived, surrounded the place, and combed it carefully, and the strange object was loaded onto a truck with great precautions, and then it departed. The inhabitants were questioned meticulously; had anyone tried to hide any object?... And during a recent meeting between the test site chief, Lieutenant General Ilyenko, and the inhabitants of Mayskiy Rayon," Kaliyev continued, "I asked him: 'So what happened, Arkadiy Danilovich, did your people lose a bomb?' 'They did not lose it, they dropped it.' And he would say no more on the subject."

What a diplomat?! However, we have already encountered the diplomacy of generals, so let us return to the investigation. Thus, by now there are four nuclear points on the map, true, still without exact coordinates. But the main thing has really been confirmed: Nuclear explosions took place not only on the test site. Does this not mean that the entire country could become a test site? USSR deputy minister for atomic energy and industry Professor V. Mikhaylov unexpectedly reinforced this wild thought with his long statement in PRAVDA in October 1990. I quote: "In various parts of the country (that is, outside the Semipalatinsk and Novaya Zemlya test sites—author's note) since 1963 some 115 underground nuclear explosions for peaceful purposes have taken place, but at great depth and having low yields, including those used to create underground cavities, extinguish fires in gas blowouts, intensify oil recovery, and make soundings of the earth's crust for large-scale surveying for minerals." The professor went on to write that in the past 10 years alone 43 such detonations had taken place. Unfortunately, there was not a word about locations. Neither was there any discussion of, for example, whether the extra oil recovered by the nuclear method had higher levels of radiation than the norms. Atomic sounding of the earth's crust is also quite cute. I would just like to know how the ground water is behaving at the sites of the soundings, and what people who do not suspect that they are drinking water contaminated with radiation are experiencing. These are not idle questions... In the second issue of PRIRODA for 1991 two nuclear physicists describe in the greatest detail how with the help of two atomic detonations in salt domes they created underground capacities into which toxic chemicals and radioactive waste are pumped and stored in perpetuity since this is economically advantageous and ecologically safe.

God forgive me, old skeptic that I am, but I find it hard to believe in the eternal nature of anything created by human hands, particularly in our country. But I am convinced that by this method we are preparing delayed-action chemical and radiation bombs for our descendants.

"... I was on the shores of Atomkul (in translation from Kazakh this means "Atomic Lake") quite recently, last autumn, as part of a large group of foreign and domestic journalists and people's deputies. I honestly admit that I shall do everything possible to avoid having to go there again. We arrived in Kurchatov at dusk. As the stern

men in uniform (no one, I believe, was below the rank of major) checked our passes at the checkpoint darkness fell. Notwithstanding the majors warned us: Cameras and video cameras must be surrendered. No photographs along the way." I almost fell out of my chair on the bus in amazement. The test site was already officially closed but this mania for secrecy persisted.

At the first news conference General Ilyenko, as always, repeated that the closure of the test site had been a mistake, that we should not be weakening the country's defenses, and that the Semipalatinsk test site is the most reliable and the cleanest in the world, and that even the Americans admit this. Probably everyone would have swallowed this lie had not an American journalist picked up the microphone and, to general laughter in the hall, stated that she had heard exactly the same words in Nevada from an American general and, of course, about the Nevada test site. To which Arkadiy Danilovich responded imperturbably:

"You can be convinced of this for yourselves. Where you will be visiting tomorrow is totally clean, with a normal radiation background."

Dozens of tape recorders, including mine, recorded these words. Later I tried unsuccessfully to understand why the general had got himself into a mess, for he was well aware of our route—the site of the first nuclear explosion, and then Atomic Lake...

Enormous melted boulders cluttered the approach to Atomic Lake, some weighing as much as a ton, thrown about in an 8-kilometer circle. You will encounter nothing similar on the steppe here. The test site people explained that in January 1965 (according to other data in December 1964—author's note) an underground nuclear explosion took place in the bed of the steppe Chagan River (which, incidentally, flows into the Irtysh) for national economic purposes—to form a reservoir. A kind of open-air physics experiment. The patter let out of the bag the fact that these boulders had been hurled out of the crater by the explosion to a height of almost a kilometer.

"So, was it an underground detonation?" I tried to get clarification from the chief of radiation safety at the test site, Colonel Samata Smagulov.

"Yes, underground," he confirmed, without batting an eyelid. This unholy lie was then repeated many times by General Ilyenko and all his subordinates. Why? For in the vicinity of the atomic lake there are thousands of witnesses to this lie. True, they remain silent—they are only stones and boulders. But anyone, even the nonspecialist, understands that in underground explosions there is none of this kind of debris, and that the boulders should remain under the ground...

We move to the lake, dosimeters in hand, chattering constantly—Japanese, American, French, Russian. No, the stones are not silent. I see a French television operator by one of the boulders, feverishly tugging on a respirator and excitedly saying something to an interpreter. She translates:

"We must leave here quickly, the radiation level is too high, about 9,000 microroentgens an hour" (hundreds of times above normal—author's note). "Is this dangerous?" she asks us.

"Not at all." The painfully familiar voice on the television debates, the cheerful voice of Colonel Petrushenko, is suddenly heard. "and to prove it I shall now take a dip in the dreaded lake."

Taking off his tunic as he goes, the colonel runs to the water shouting.

"In the summer Nevzorov and I ate fish soup here..."

The colonel splashes about in the atomic lake, calling on his 12-year-old son to jump into the icy October water, promising everyone who joins him a shot of that spirit that is in such short supply here.

The dosimeter chatters desperately but it is as if we do not hear it. It is like some kind of theater of the absurd with atomic scenery.

A real nuclear catastrophe occurred here, and as a result more than 200 people perished. Perhaps the military people really did plan an underground explosion to have the Ashes run into the Chagan, but that is not what happened; either there was a mistake in the calculations or a nuclear surprise. It is a secret that we are unlikely to learn. But you cannot hide the result: the explosion was a ground detonation and about 3.5 million cubic meters of earth, ashes, and rocks were hurled out from the epicenter.

One of the cleanup crew, Vladimir Zhirov from Ust-Kamenogorsk (he is now chief of a production dispatcher service in the Irtyshsk Construction Administration, but at that time was a junior foreman with the secret "Post Office Box No. 16") said this:

"I was 23 at the time, and I was strong, very strong. But I spent several days at the epicenter and admitted that I was tired: I started to have nosebleeds, my throat scraped like emery paper, and I started to choke and had an excruciating headache... It was terrible then; everything for kilometers around was strewn with radioactive ash. It had to be carried away so that it would not be carried into the Irtysh River in the spring. We worked conscientiously, did not spare ourselves. One bulldozer driver went into the atomic water with a hawser to save a bulldozer. He saved the bulldozer, but he did not last for long; he died. As for me, I left the site of the fire with chronic decorations—bleeding from the nose, disease of the pancreas, bronchitis, cholecystitis, hepatitis..."

According to Zhirov, of the 300-strong cleanup crew (the entire detachment was formed in Ust-Kamenogorsk) about 30 people are still alive. This has been the cost of an atomic explosion for peaceful purposes. Now, those

who are still alive are fighting for their rights and privileges to be put on the same footing as those who suffered in the Chernobyl catastrophe. The atomic department is responding with indifferent formal replies...

The theater of the absurd also continued at the final news conference with General Ilyenko. At the insistent request of the journalists the general ordered a radiation safety (or danger?) map of the test site to be brought out. Territory with a radiation background of up to 50 microroentgens an hour (moderate) was colored yellow; blue signified 100 microroentgens an hour (undesirable to stay in the area for long), red up to 10,000 microroentgens an hour (very dangerous). Three minutes later the general gave another order:

"That's all, remove the map, we do not want the whole world to know about it."

He was splendid in his desire not to leak a secret. He sincerely failed to understand why anyone other than himself needs to know. And I sincerely failed to understand why this map is not published, why it is not distributed to the sovkhozes bordering the test site that on the sly drive their cattle to graze not only in the yellow zones on the map, but also the red zones. We saw the tracks of domestic animals on the shores of Atomic Lake. We saw people loading bales of hay onto a vehicle at the site of the first nuclear explosion, where 42 years later the readings are as high as 10,000 microroentgens, while cows grazed nearby.

"Those are not our animals," Ilyenko said,"we have none there. We have forbidden grazing but they do not listen to us. We check our animals and our milk regularly, and conduct analyses. Everything here is normal."

"Why did they not warn us that we would encounter high levels of radiation at Atomic Lake and in the area of the first nuclear explosion?"

"I did not want to take you there at all. This was 'Nevada's' idea, they insisted. But I am sure that what you received in two hours at the test site was quite safe, even beneficial for the body to some extent."

We have come that far. The only thing the general did not do was add that the test site was quite suitable for the construction of a resort zone.

I realized that only independent experts can tell the full truth both about the secrets of the test site and about the nuclear explosions around it. I marked Atomic Lake and the approximate boundaries of the test site on my map. On that same trip I succeeded in learning about a source from whom it might be possible to pick up information about other nuclear explosions for national economic purposes. I am not about to tell you how I obtained it, but I have in my hands a document about 25 atomic explosions in various oblasts of Kazakhstan (my source claims that there were about 40). The document is genuine, signed by the minister of atomic energy and

industry, V.F. Konovalov. The document lists the years and sites where explosions took place (without indicating the yields), and also the depths, designations, and nature of the radiation situation after the experiment.

This is what it states about the situation: "Recultivation work is being carried out on the technological areas." Excuse me: If we are talking about recultivation (what, it has been going on for more than 10 years?) then this means that the surface must have been destroyed, does it not? Is this possible with underground explosions? Or do we have more dark secrets here? As before, I also have grave doubts about the harmlessness of underground explosions and about the purposes for which they took place—for military purposes on the test site, for peaceful purposes outside it.

Unfortunately, these doubts are not groundless. In 1973 two atomic explosions for peaceful purposes took place in Chimkent Oblast to make seismic soundings for the purpose of finding structures that would be promising for mineral surveys. So, first "Meridian-2" was set off at a depth of 400 meters in Suzakskiy Rayon (260 kilometers to the north of the settlement of Chulak-Kurgan), and then "Meridian-3" at a depth of 610 meters in Kzylkumskiy Rayon (40 kilometers north of the settlement of Tabak-Bulak). The situation was described as follows: "There have been no excursions of products from the explosion and the site has been closed." That is, do not worry, citizens, everything is in order, everything is as it was before, maybe better.

I do not know whether or not anyone found any minerals for the motherland but the "products" have in fact appeared, and the inhabitants of precisely these rayons have started to complain of deteriorating health. This year (17 years after the explosions; it could not be done earlier because no one knew about them) a commission independent of the Ministry of Atomic Energy and Industry (scientists, physicians, geologists, public figures, ecologists) was set up "to study the ecological situation and the health of the population in Kyzlkumskiy and Suzakskiy rayons in Chimkent Oblast in connection with existing production facilities for uranium, scandium, and other rare-earth elements with respect to underground leaching, and also the nuclear explosions that took place in the 1970's." The words here in quotation marks are taken from the official conclusion sent by experts to the president of Kazakhstan, N. Nazarbayev. Their conclusions are disquieting. I quote: "In the underground water in both rayons strontium-90 was found, and in six bore holes cesium-137 was found, which testifies to radionuclide contamination of the water-bearing horizons. In Suzakskiy Rayon... anomalous concentrations of radioactive elements were found in underground water in 39 bore holes... Analysis of the statistical data on the state of health of the population has shown that... 65-70 percent of the total number of oncologic diseases are cancers of the esophagus, stomach, and liver... The incidence of tuberculosis and diseases in organs of the gastrointestinal tract has increased by a factor of 1.5-2.5... Because of the presence

in underground water in Kzylkumskiy and Sizakskiy rayons of strontium-90 and cesium-137 we demand that the Ministry of Atomic Energy and Industry study water containment in the cavities formed by underground nuclear explosions across the entire territory of the Kazakhstan Soviet Socialist Republic. If leakage of radionuclides from the explosion cavities into stratal water is found, the leaks should be eliminated."

Fair demands, and naive. I do not know what President N. Nazarbayev had to say on the subject, but personally I doubt that it would be possible to stop the radiation that has already penetrated into the ground water, or eliminate the leaks. How would it be done? Could one more nuclear charge be used to seal off everything? Incidentally, this not a joke. It would be a doubtful thing to entrust the monitoring of underground cavities to those same atomic people, because their answer would be the same as always: Everything is normal.

No, it is independent experts who must monitor for the atomic people. It is essential to immediately make public all preparations for atomic explosions for so-called national economic, peaceful purposes, and even better, stop them. It is essential to make public a complete map of such explosions. And it is time to close down the theater of the absurd and remove the scenery.

[Box, p 15]

Lest I bore the reader, let me cite only a small part of the information that I gleaned from the document signed by V.F. Konovalov:

Some explosions were given cutesy code names. For example, "Lira-1, 2, 3, 4, 5, 6." That is, six explosions took place under the code name "Lira" in 1983-1984 at depths of 840 to 990 meters in order to create underground cavities in a salt dome (in Burlinskiy Rayon, Uralsk Oblast, 17 kilometers north of the village of Ilek). Other explosions are designated simply by figures and letters. Thus, in Yeraliyevskiy Rayon, Mangyshlak Oblast, three explosions, 1-T, 2-T, and 6-T, took place 110-115 kilometers east of the village of Say- Utes in 1969-1970 at depths of 410-740 meters; "there was no excursion of products, subsidence craters were formed." The question is: What happened with 3-, 4-, and 5-T? There are many such omissions in the table... To judge from the document, the last explosion took place in 1987, the earliest—"A-1"—in 1966 in Dengizskiy Rayon, Guryev Oblast, at a depth of 160 meters. And there, in recent years, right through to 1979, another nine explosions took place (for some reason "A-6" is omitted) within a radius of 20 kilometers, true, now at depths of 600 to 1,500 meters. Essentially, it is just another test site.

Trajectory of the Kurchatov Star

[Interview with S.Kh. Khakimov and S.V. Antipov by correspondent V. Yegikova; two uncaptioned photos omitted]

[Text] Do you recall whether there is another institute in Moscow besides the Kurchatov that has experienced so many changes in public perception? The amplitude of these changes has always fluctuated sharply—from total secrecy to a halo of glory, from total indifference to sharp displeasure, from open anger to involuntary admiration. And now once again there is indifference.

It used to be discussed in whispers, and then only by the initiated. There were few who knew what was hidden behind the fence that appeared in the early forties in one of the then-remote outlying districts of the capital. The years passed and the history of the creation of the first Soviet atomic bomb grew in legends. The institute founded by Igor Vasilyevich Kurchatov has received his name, and the words "nuclear icebreaker," "nuclear power plant," and "nuclear reactor" have become a part of our lexicon.

At first, they entered with a plus sign. Later they would become associated with terrible misfortune and catastrophe, and the enormous territory of the "Kurchatov" would be perceived in the mass consciousness as a gloomy symbol thereof. This image, circulated by the "greens," has spawned open animosity with respect to the physicists who were never idolized. And then, on all corners, talk began about the new potential threat associated with them: Who is making certain that the nuclear engineers will not go and build the bomb for some Hussein or Qadhdhafi?

Following these conversations came an almost unnoticed event that was of arch importance not only for the Atomic Energy Institute but for science in general: A research collective called the Kurchatov Institute Russian Scientific Center was created on the basis of the institute by order of the president of Russia. The document was signed by Yeltsin at the end of last year, and intensive development of a policy to serve as a basis for the center's operation is now in progress. What was the purpose of creating the center and why was the presidential order received with such hope at the "Kurchatov."

To get answers to these and other questions, we sent our photocorrespondent Aleksandr Volodin to the old Khodynka rayon, where an entire institute minicity has grown up. The photographs presented here will help the reader look inside the gates of the "Kurchatov" if only for a few moments. Indeed excursions throughout its grounds are still not open to everyone. And the situation is hardly likely to change in the foreseeable future: The institute remains closely guarded, but not because secrets are being protected. The shroud was been removed from

Figure 1

many of them after I V. Kurchatov's famous report at Harwell in 1956. Both our safety and yours must be strictly guarded!

Admittedly, the slight misunderstanding involving the pass made out in the name "correspondents" that kept me hanging about at the entrance for half an hour did not cause any anger, as would have surely been the case in any other case. Indeed, I even felt gratitude toward these stern fellows for whom my identity card was nothing more than a worthless piece of cardboard. I involuntarily understood that I was also guilty of the very same phobia that many associate with the name of this research giant. This phobia, which has become ingrained in the post-Chernobyl consciousness, has compelled the institute's administration to erect an enormous indicator board over the central entrance illuminating the radiation background. This innovation should convince the passer-by that the level does not exceed the natural background level. Inside the institute itself it has been firmly established that the ecological situation in the microregion is nearly the calmest in the entire city.

We saw yet another indicator board. This one was already deep into the institute's territory, where densely planted evergreen alleys lead to the various buildings and facilities. One of them, while in no way remarkable from the outside, was actually the entrance to the building where the very first reactor was created by the Beard, which is what they called Kurchatov behind his

back. Much has changed at the institute since that time. Now there is nuclear power generation, controlled thermonuclear synthesis (which promises to give people the most inexpensive and safe energy source), and medical and ecological research....And so the Atomic Energy Institute is more than just reactors.

But we must stop using its old name. Today it is the Kurchatov Institute Russian Scientific Center. I asked S.Kh. Khakimov, deputy director of scientific work and doctor of physical and mathematical sciences, and S.V. Antipov, his assistant director and candidate of physical and mathematical sciences, what lies behind the name change. Here are several excerpts from our conversation as recorded on my reporter's Dictaphone.

[S.Kh. Khakimov] The objectives of the creation of the Kurchatov Institute Russian Scientific Center were formulated in the first pages of the presidential order, which spoke of implementation of a state scientific-technical policy in the sphere of the development and assimilation of safe and ecologically pure methods of producing power, the creation of the conditions necessary to develop the R&D conducted by the Atomic Energy Institute, and the need to make more efficient use of the scientific-experimental base that has already been created. Not only does the institute retain all its rights, but various enterprises, institutions, and organizations will also be included in the center based at the institute. We have never before had anything analogous to this type of scientific-research community.

[Correspondent] And is it not something akin to a concern or corporation?

[S.V. Antipov] Not at all. Creation of the Russian scientific center was the result of a natural evolution. In its time the Kurchatov institute was created to solve a distinct applied problem. At the time, it was entirely logical for it to become a part of the Ministry of Medium Machine Building [Minsredmash] and later the Ministry of Atomic Energy and Industry. But the institute gradually began devoting an increasing share of its resources to basic research, and it became more closely tied to the Academy of Sciences. And this above all prevents us from becoming locked within the framework of a concern or corporation. At the same time, basic science has a unique character at our institute. It is generally very resource intensive, is developed on a strong experimental base, and will eventually be directed toward practical results. Here all scientists and researchers are able to complete the entire chain from basic theoretical research to exploratory and applied research and on to the creation of the latest technologies and to the embodiment of their ideas in finished products.

[S.Kh. Khakimov] It is precisely for that reason why we cannot merge into the academy. I will just say that we have as much fixed capital, amounting to a billion in the old prices, as the entire academy altogether! If we were to merge into the academy, we could, to put it bluntly, either "deluge" it or create a regular monopoly. So when the question of the fate of the Ministry of the Nuclear Power Industry [MAEP] arose, we had to think about our own. Our version is unique in many respects. Above all, it is unique in that a certain impression has formed at the state administrative level that we are neither a ministry nor an enterprise....

[Correspondent] In other words, you have achieved what every institute dreams of, namely, total independence?

[S.Kh. Khakimov] You see, once more I would like to stress the word "unique." That is because each institute, like each star, has its own fate and its own trajectory. We are not speaking simply about independence but about the creation of a national center. So it has come to pass that a great deal of wealth has been concentrated at the Kurchatov institute. Above all, it is in the form of human potential and very great scientific strength. Second, there is its big research and experimental base, namely, lasers, accelerators, tokamaks, and reactors. All of this has made it possible to move out along a trajectory (if I may be permitted to use the same image) that not everyone is able to follow.

[Correspondent] But it was the solid financing provided first by the Ministry of Medium Machine Building and later the Ministry of the Nuclear Power Industry that by and large made it possible for the institute to concentrate this wealth. How will your budget be put together now?

[S.Kh. Khakimov] First, the presidential agreement contains a special agreement regarding matters of supporting the center. Above all, this means state financing.
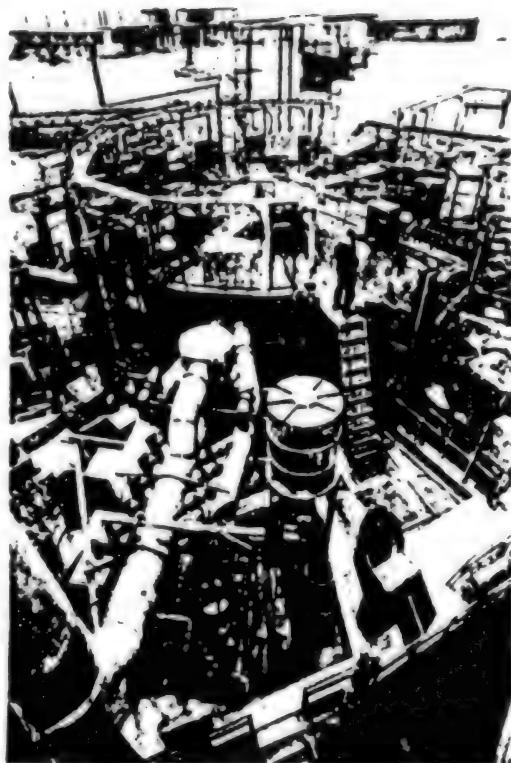
Figure 2

But we will of course be unable to rest solely upon it. And there is no such possibility at a time when we are seeing just how difficult it is for the government to adhere to a deficit-free budget. Under these conditions, it is more likely that even those scant resources that have been allocated for science will be cut...We are proposing that a portion of our financing will come from participation in competitive scientific programs. We will earn money by reaching direct contracts with clients to perform applied research. Finally, we have considered structures of a commercial nature.

[S.V. Antipov] And the ratio of all these sources of income should be such that the center conforms to its designated purpose. If a portion of the resources for its research are allocated from the state budget, in other words, if the taxpayers' money is used, then they will always have the right to ask how the money is being spent. And the higher the level of the work performed, the greater the chance of winning a competition and concluding a favorable contract. We will thus determine our own fate.

[Correspondent] It is no secret that the attitude toward nuclear engineers in society is complicated. Does the psychological discomfort associated with this fact hinder your work in any way?

[S.Kh. Khakimov] I would not mentioned any psychological discomfort. The people working at Kurchatov institute are experienced and devoted to their work, and
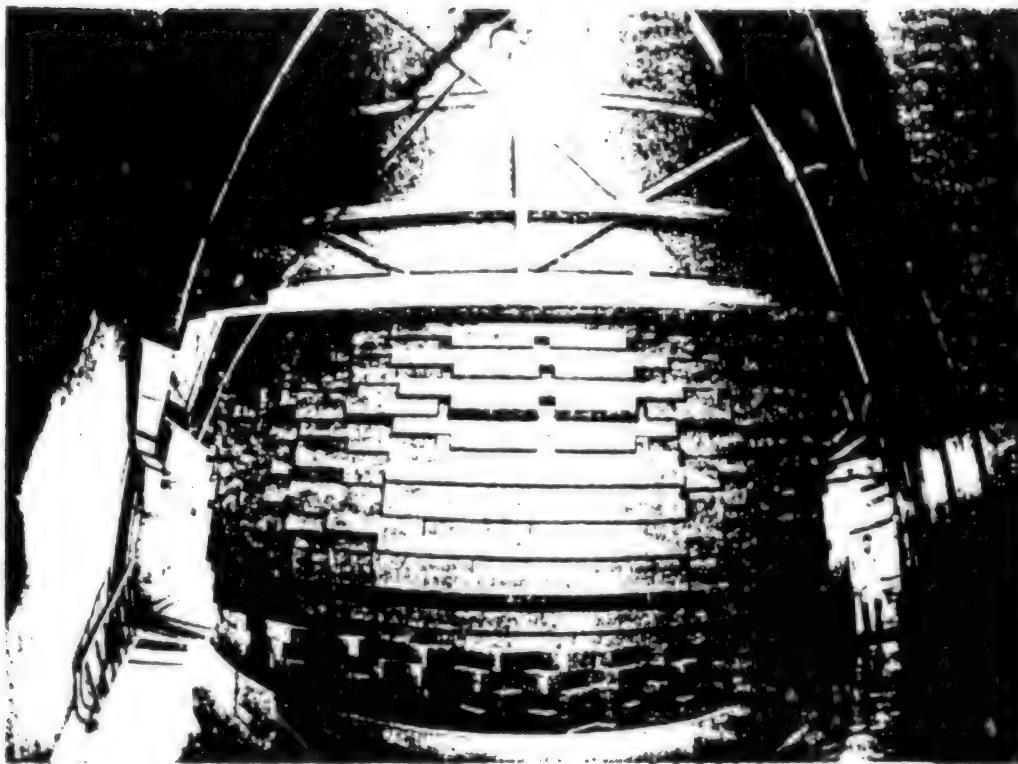
Figure 3

they understand the importance and necessity of their work. Indeed the same research reactors that people want to have removed from Moscow are needed to safeguard the reactors operating at nuclear power plants Dismantling our units without a clear rebasing program would not be an escape from danger but in fact would make things more dangerous. This is not even to mention the fact that this type of an unprepared shutdown of the reactor would eliminate a serious diagnostic base of dozens of cardiology, oncology, and other clinics. Preparations for staged withdrawal are another matter, but we need a program and tools here

But if you are talking about the consequences of persistent guardedness toward nuclear engineers and physicists, that is an area where there is great danger. I repeat Today we have the most experienced people working here. But who will come tomorrow? The biggest trouble that we see is the collapse of higher education. It is in such a disastrous state. The prestige of knowledge and higher education has fallen so low that the influx of fresh forces and talented youth declines each year. We are trying to maintain very close contacts with higher educational institutions and to guide nourish, and help youth, but... Today this is not a simple matter. There are of course, young people who have fallen in love with science, but a great many are leaving to enter a sphere that is now more prestigious or that pays better

Tomorrow nuclear power engineering may end up in the hands of mediocre specialists—that is the real danger!

[Correspondent] Let us add, that scientists are leaving...

[S.V. Antipov] They are leaving....They are retiring or else working on short-term contracts. You are right in that the problem does exist. But the uproar raised about the highly exceptional departure of physicists to the countries of the East is more on the order of propaganda. Such conversations are most likely being stirred up by that portion of society that does not want to become reconciled with the loss of their former might. Or else they are in the palm of certain countries wishing to entice specialists that way

Another problem is that a scientist is truly given every opportunity to do valuable work and that he should be paid fairly for it. Then we would be assured that the youth would come to us and that the "suitcase" matter would be closed

[Correspondent] Can you count on the fact that a national center would help things? As far as I am aware, the new minister responsible for state scientific-technical policy likes to repeat that if you cannot give people money you must give them freedom

[S.Kh Khakimov] That is a good formula. The program that is now being developed to carry out the presidential

order is largely based on it. We will be able to adhere to it, and success will come. Will we be able to use this freedom sensibly? Let us meet at the national center after a bit of time has passed, and then this question will be answered. For now, we must work!

The New World—Is It the Promised Land?

927F01704 Moscow KRASNAYA ZVEZDA in Russian 1 Apr 92 p 4

[Discussion between V. Zaytsev, G. Zolotukhin, A. Matushchenko, V. Bitkov, V. Dumik, and A. Tsubanikov moderated by KRASNAYA ZVEZDA correspondent A. Pilipchuk, capt 2d rank; first three paragraphs are KRASNAYA ZVEZDA boxed introduction]

[Text] The last underground nuclear explosion at Novaya Zemlya took place on 24 October 1990. On 29 October V. Karpov, the USSR Deputy Minister of Foreign Affairs, met with delegates of the Western European countries. He deemed the explosion "necessary" in view of the fact that other nuclear powers are continuing their tests and that unilateral cessation of testing had already begun to have an effect on the country's security.

Accompanying the physical characteristics and political "wake" of the Soviet Union's last nuclear explosion was a great deal of "fallout" in the form of public protests. But the voices of those who, by the will of fate, have been charged with forging the state's defense capability at the burning nuclear "crucible" have yet to be heard among the chorus of voices.

In an awareness of this fact, the editorial staff has therefore invited Admiral V. Zaytsev, deputy commander of the CIS Navy, to meet with a group of specialists who have worked for many years testing nuclear weaponry at the Novaya Zemlya proving ground, namely, G. Zolotukhin (State Prize laureate and vice-admiral), A. Matushchenko (doctor of technical sciences, professor, and colonel), V. Bitkov and V. Dumik (both candidates of technical sciences and capts 1st rank), and A. Tsubanikov (capt 1st rank).

[Correspondent Pilipchuk] In today's times acting in the role of an advocate of the military-industrial complex is a thankless task...

[V. Zaytsev] This year alone a number of domestic and foreign mass media have addressed this theme, representing us as monsters and calling our activity the crime of the century. During the course of all this, purely populist techniques designed for ignorant people have been set in motion. For example, there has been a great hullabaloo over the apparent dumping of spent nuclear fuel into the sea. And the proving ground has been blamed. Its task, as determined by the respective political decisions, has been to conduct underground nuclear tests. The proving ground has no sites for burial or storage of radioactive wastes. No spent nuclear fuel from ship reactors is buried here; it is sent to be regenerated. There has been no intentional dumping of highly active

wastes into the sea. The only thing that can be cited is the burial of wastes that do not contain any fuel components and that have a low activity level

[G. Zolotukhin] Between 1946 and 1982, all countries throughout the world that were developing nuclear power continued to dispose of their wastes in the seas and oceans. At the time the method was considered safe, and it was least expensive. Between 1971 and 1978, the United States, England, Belgium, The Netherlands, and Switzerland regularly dumped wastes into the sea, and France, Italy, the FRG, and Sweden did so episodically. Between 1967 and 1982, about 188.190 containers containing 94,000 tons of waste were dumped into the Atlantic. And in 1975, after the London Convention on Dumping Wastes at Sea, the process began to be regulated with a total ban on the dumping of highly active wastes. In 1983 the Seventh Consultative Conference of the convention adopted a resolution calling for the cessation of the practice of dumping radwaste into the sea in 2 years. The United States, England, and Japan voted against the resolution, and France, the FRG, the USSR, and several other countries abstained from voting

As far as the proving ground at Novaya Zemlya is concerned, it has no relation whatsoever to the dumping of radwaste into the northern seas

[V. Zaytsev] Moreover, a moratorium was put in place for additional study of the effect of sea burials on the ecology. The results were considered at a consultative meeting of the member countries of the London convention in 1985. It was acknowledged that the problem causes a great deal of discord. In my view, burial on dry land is even more problematic.

[A. Tsubanikov] Consideration must be given to the fact that the induced activity of the buried materials is comparatively low and that, by the time the containers rupture, it drops to an insignificant level. Multiply repeated studies monitoring the situation in individual regions where radwaste has been dumped demonstrate that the radiation level at the sites does not exceed the background values.

[Correspondent Pilipchuk] I am well aware that sitting before me are a group of people whose fates are linked to the "military" atom. Most of you have spent many years at Novaya Zemlya. Your children have practically been born right alongside the battlefields of the proving ground....Of course, such arguments make an impression. But your opponents publish facts that stun the imagination. One example is the fact that mortality among reindeer breeders is double to triple the country average.

[A. Matushchenko] Let me tell you what Hans Vliks, the general director of the IAEA and a world-class authority in the field of nuclear power generation has said. He said. "We must talk about a large group of journalists who are not scientific specialists as would appear from their writing. We often see articles published in the USSR and in other countries that reflect events that may be linked to radiation but that may not be either. For example, there are photographs of some calves with six legs. And

whether this really happened because of the effects of radiation or not is unknown because such calves may also appear in Australia or Argentina...."

As far as the short life span of reindeer breeders is concerned, consideration should be given to the fact that reindeer breeders live under the effects of extreme factors.

[V. Bitkov] Talk in the press about radiation and the ecological consequences of nuclear explosions is often based on emotions. The authors are trying to bypass the source physical information. Not long ago a number of people's deputies and journalists representing the main northern regions of Russia visited the proving grounds. The "invasion" landed fully armed with Japanese and French personal dosimeters and photographic equipment. They made measurements at the wells and tunnels. They were assured that the background values were lower than in Moscow. They filmed the instrument readings and the panorama. And then slanderous materials stating that Novaya Zemlya was a nuclear dump appeared.

[A. Matushchenko] Incidentally, since 1968 the foreign monitoring services have used first-class equipment to track our tests, and if any radioactive contamination beyond the confines of the 12-mile zone around the proving ground appeared, they would immediately send a memo or note....

[V. Dumik] I have served directly on the proving grounds for 8 years, have lived there for 7 years, and have two daughters. We examined everything there—the conditions at the proving grounds, the air, the water, the soil, and the animals. Since 1989 objective materials regarding radiological conditions at the proving grounds have been reported and sent to the Murmansk and Arkhangelsk oblasts. But the local "greens" do not use them. They do not fit into their scheme of diatribes. It is much simpler to write, for example, that the reindeer around Novaya Zemlya are dying from radiation. And they are writing this at a time when the population of this species of reindeer and white bears are actual being restored, as has been confirmed by numerous research studies.

[Correspondent Pilipchuk] I have wondered about the phenomenon of the social movement called the "greens." They are like Greenpeace, for example. In the 20 years of its existence it has been able to win the respect of millions of people who are not indifferent to the fate of civilization and to instill in them the fear that they are destroying nature.

[A. Matushchenko] The environmental protection movement is pursuing noble goals that are shared by hundreds of millions of people. It has "compelled" us to respect ecological needs. And its alternative, competitive inspection has impressed us overall. That is how it should act. But we have long called attention to another side of Greenpeace's activity, namely, its distortion of information (for example, inflating the contamination levels at

Novaya Zemlya a thousandfold) and their theatrics. The influential journal DER SPIEGEL recently unexpectedly confirmed this. Here is an excerpt from the publication: "With the help of daring maneuvers on inflatable rubber boats and loud public measures, Greenpeace has been transformed into the richest organization in the world. While other environmental protection organizations guard every mark, the [word illegible]-ecologists recently erected an entire magnificent home for their institution in Berlin. 'Long-range plans that extend beyond the scope of a primitive protest are required in order for it to be feasible to spend many millions. But even they have not been provided,' states Wolfgang Zangel, the former director of department of energy and atmosphere of Greenpeace in Germany. Zangel, a renowned ecologist-scientist and publicist, left the organization after only half a year of work. He was uncomfortable with the "lobbyist decision-making method" and "ruthless filtration of published information." In actual fact, Greenpeace never cared about which ecological problem required the most immediate solution; instead, it concentrated its attention on striking symbols. While self-advertisement was previously only a side activity for Greenpeace, its work for the sake of its own self-image has increasingly become an end in and of itself."

The problem is that those who are assuming the role of defenders of nature have no concrete proposals regarding where to put the inevitable wastes of nuclear power generation, industry, and the defense complex.

[Correspondent Pilipchuk] Your opponents nevertheless propose a way out—halt the tests....

[G. Zolotukhin] Unilaterally it will accomplish nothing. The second moratorium on underground tests—this time the Russian one—is ending this year. Not one country has joined us. Russia has become the main recipient of the nuclear "heir" of the USSR. I do not think that the Russian politicians were aware, when they made such a decision, that the threat of nuclear war demands preservation of their testing infrastructure.

[Correspondent Pilipchuk] So what have we come to, and where will we go in the future?

[V. Zaytsev] The problem is of the utmost importance—to create a state program to handle radioactive waste and spent nuclear materials and to recover and bury them. The Navy has knocked on the doors of no fewer than three governments that have replaced one another, each time arriving with concrete proposals and developments. Finally at the end of June 1990, the first Congress of RSFSR People's Deputies issued such a decree. In November 1991 the president of Russia gave the government permission to take emergency measures to safeguard the republic's territory against radiation.

[G. Zolotukhin] Proposals related to operation of the Novaya Zemlya proving ground have also been taken under government consideration. The problem now is to get wise political decisions that are as dispassionate as possible.

A Study of the Geotechnological Conditions of Hydrogenic Deposits From the Standpoint of Their Development by the Technique of Underground Leaching

[Article by K.G. Brovin, Krasnokholmskgeologiya Polar Geophysical Observatory, and V.V. Ten, experimental-methodological team; UDC 553.061.6.005]

[Abstract] Published research has shown that the method of on-site underground leaching through a system of service wells drilled from the surface is the optimal method of exploiting exogenic epigenetic deposits of uranium. The high efficiency of underground leaching has resulted in a slackening of industrial requirements regarding the quality of uranium ore, which has in turn made it possible to adopt a fundamentally new approach to the problem of extracting a number of valuable ores from the earth's depths, such as rhenium, scandium, yttrium, and a number of lanthanoids that are all present in ores in low concentrations. Thermodynamic calculations of fields of the preponderance of the said ores in liquid and solid phases have been performed in order to develop a theoretical basis for estimating the physicochemical requisites for their underground leaching, and regions with geotechnological conditions conducive to leaching have been identified. These calculated data have been confirmed in experimental studies. The Krasnokholmskgeologiya Polar Geophysical Observatory has developed and is now successfully using a method of studying the geotechnological conditions of polyelement epigenetic deposits. The new method makes it possible to eliminate sites where use of underground leaching is not promising. Hydrotechnological studies are conducted throughout all stages of the study of the polyelement metallizing process. Two main types of studies are performed: laboratory and full-scale tests (the latter are conducted at the site where the ore is located). In the laboratory (preliminary) testing stage productive solutions are subjected to filtration leaching in filtration tubes to assess the feasibility of underground leaching. The Krasnokholmskgeologiya has created a special geotechnological laboratory to collect the data required for feasibility studies and for preliminary exploration and substantiation of full-scale experiments. During the first stage of the full-scale testing, which is conducted at the ore site, a decision is made as to whether pilot commercial tests (the second stage of the full-scale tests) are required. The main purpose of the said tests is to determine lithologic-filtration characteristics, identify toxic additives, and determine the exact nature of the polyelemental distribution pattern encountered. The familiar procedure for full-scale testing of monouranium deposits is used in conjunction with a mandatory evaluation of the conditions required for leaching all of the metals found to be present (generally between three and five types are found). Detailed geotechnological well logging is conducted solely in sample segments along the grid of the deposit being explored. Exploratory wells 50 to 100 x 25 m are logged. The main purpose of the full-scale testing is to obtain a complete list of the values of the geotechnological indicators of the underground leaching process and the surface processing of productive solutions required to produce a commercial product. The results of the pilot commercial tests (including an exact determination of the concentrations of all metals found to be present in the productive solutions identified) serve as the basic source data for compiling the plans for development of the polyelement deposit by means of underground leaching. The approach adopted by the Krasnokholmskgeologiya Polar Geophysical Observatory is recommended for use in studying polyelement epigenetic deposits as a way of optimizing the geological prospecting process. Figure 1, references 6 (Russian).

Atlas of Level-by-Level Maps of the Central Kyzyl Kum Ore Province

[Article by O.N. Krylov, Exploratory-Photographic Expedition; UDC 528.9(084.4):553.495(575.1)]

[Abstract] The chalk deposits of the Central Kyzyl Kum have been shown to contain commercial uranium ore deposits of a new genetic type controlled by zones of seam oxidation. All of the exogenic epigenetic deposits are concentrated within the confines of four large uranium ore provinces (the Central Kyzyl Kum, the Bukhara-Khiva, the Syr Darya, and the Chu-Sarysu) that are united into the Prityanshan (i.e., near Tyan Shan) megaprovince. At the beginning of the 12th 5-Year Plan, plans were made to summarize existing material on the geological structure and uranium content of the megaprovince on a scale of 1 to 1,500,000. The primary objective of this project was to discover useful laws in the localization of the uranium deposits, assess the promise of finding raw materials for use in power generation in the southern USSR, and determining how much uranium would be available to existing enterprises. The task was completed in 1986. The atlas compiled was the first for the entire territory of the Prityanshan megaprovince. The atlas' 33 level-by-level maps illustrate the main geologicostructural, lithologicopaleogeographic, hydrogeological, and lithologicogeochemical conditions of the localization of the epigenetic-seam uranium deposits in the Mesozoic and Cenozoic sediments of the province. The atlas has received high marks from the scientific-technical coordination council in the field of geology and was awarded a prize by the USSR Ministry of Geology. Plans were then formulated to conduct more detailed metallogenic studies in the Central Kyzyl Kum ore province, which has the most developed ore recovery industry of the megaprovince's four provinces. The creation of a new atlas of level-by-level maps detailing the 180,000 km^2 Central Kyzyl Kum ore province was virtually complete by the beginning of 1991. The new atlas contains 39 graphic pages: a title page, a legend page, and 37 specialized maps compiled on the basis of

35 years' worth of exploratory and prospecting drilling (in the form of over 20 million meters of wells) conducted by the Krasnokholmskgeologiya Polar Geophysical Observatory. Included among the maps are 11 maps providing a level-by-level look at the structure of the deposits formed during the Earth's different geologic periods, 11 lithologicogeochemical maps detailing the location of uranium and related mineral deposits, 6 maps detailing the various aquifer systems in the province, and a map forecasting the presence of uranium and related ores in the ore province.

Regenerative Heaters for K-1000-6/25 Turbine Systems for AES With VVER-1000 Reactors

927F0112B Moscow TEPLOENERGETIKA in Russian No 11, Nov 91 pp 27-34

[Article by B.F. Vakulenko, candidate of technical sciences, Red Boiler Maker Production Association; UDC 621.165:621.311.22]

[Abstract] In the 8 years that have elapsed since the start-up of the first 1,000-MW monounit at the Yuzhno-Ukrainsk AES, it has become apparent that their high- and low-pressure heaters are plagued with a number of design, manufacturing, and performance flaws. One of the main sources of these problems has been the decision to place undue emphasis on cost reduction and not give adequate consideration to reliability concerns. Flagrant violations of accepted water-chemical regimens has been another big source of problems, as has overloading of the steam condensate tracks of both high- and low-pressure heaters with steam dumped from moisture separator/reheaters. The main problem of the PV-2500-97A high-pressure heater to date has been the partial loss of integrity of its pipe systems due to defects in the weld joint connecting the spiral coil and header and due to corrosion-erosion damage to the intake sections of the spiral coil. Some of these defects have already been eliminated, namely, the damage to the 32-mm-diameter pipeline dumping air from the pipe system when it fills with water, the loss of integrity of the flanged joints of the two vessels, the outer erosion wear of the pipe system components due to steam condensate flows, and the outer erosion wear of the spiral coil in the condensate cooling zone. Because further improvement of the reliability of the PV-2500-97A high-pressure header within the framework of the header-spiral structure design does not seem realistic at the present time, the Red Boiler Maker Scientific Production Association has developed new chamber-type high-pressure heaters with a Π-shaped heat transfer surface made of 16 x 1.4 pipes of 08Cr14MoV steel or from 12Cr18Ni10Ti steel with the feedwater chamber located on the bottom. The new chamber heaters (designated PVD-K-2550-12A) have been designed so as to be maximally interchangeable with PV-2500-97A heaters so that they can be installed in existing AES without the need for any major alterations. The Atommash Production Association is already manufacturing the new heaters. The problem of improving low-pressure heaters may be reduced to

solving two specific problems: achieving the design heat efficiency of vacuum PND-1 and PND-2 (PN-1200-25A) and making the operation of PND-3 (PN-3000-25A) pipe systems more reliable. In an effort to remedy these problems, the fast-acting steam dumps of the said heaters were redesigned in two stages. First, the steam dumps were "walled in" with epoxy resin and outfitted with a drain nozzle to discharge accumulated condensate and keep the air nozzle from filling with condensate. Next, the steam dumps were completely redesigned. As a result, condensate heating increased from 7.5-14.2 to 29.2-31.2°C, condensate underheating decreased from 35.4-42 to 2.1-3.4°C, and the steam flow rate and load of the discharge pumps increased by 140 t/h. Measures were also taken to bring the operating reliability of the PND-3 up to design levels. The reliability of the OKG-500 condensate coolers was also improved by replacing the steel used in manufacturing their heat exchange pipes. Since 1990 the pipes have been made without a flanged joint between the feedwater chamber and pipe system. Figures 4, table 1; references 4 (Russian).

Natural Convection in the Heat-Insulated Channels of the Upper Section of Type VVER Reactors

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[Article by P.A. Andreyev, doctor of technical sciences and professor, B.L. Paskar, candidate of technical sciences, A.V. Shchedrin and V.B. Yurkovskiy, candidate of technical sciences, Leningrad State Technological University, Central Boiler and Turbine Scientific Research and Design Institute imeni I.I. Polzunov Scientific Production Association, and Leningrad Machine Building Institute; UDC 621.039.56]

[Abstract] Most of the research that has been conducted on natural convection in blind vertical cylindrical tubes such as the channels of the upper section of VVER-type reactors has focused on heat emission processes. In this research the distribution of coolant temperature is assumed to be specified and uniform throughout the channels. The effective heat conduction in the axial direction for a coolant column in a vertical pipe under the assumption of turbulent natural convection is used to calculate the temperature conditions of the structural units of the upper section. Because the data obtained by using such assumptions do not conform to existing experimental data, the authors of the study reported herein conducted their own examination of natural convection in the heat-insulated channels of the upper unit of type VVER reactors. To study the effect of structural inserts (such as the channels of the reactor control and protection system and heat and energy release monitoring systems) on the heat transfer process, the researchers constructed a special stand and conducted a series of experiments. The stand consisted of a heat-insulated vertical cylindrical tube measuring 102 x 6 mm that contained three sections (from top to bottom): a

heated section, a test section, and a cooling sections. The change in coolant and wall temperature along the height of the test section and the amount of heat released through the test section were measured. Heat was supplied to the tube by electric heaters, and heating coolant circulated from the top down throughout the heated section. The measurements were made in the presence and absence of inserts simulating the aforesaid reactor system channels. Analysis of the data from the experiments revealed that the presence of structural inserts does not impair the linearity of the coolant and wall temperature distribution throughout the height of the test section. In all cases, the presence of structural inserts simulating reactor channels resulted in a reduction in the temperature gradient and spread of the pulses occurring under identical heat loads. The maximum discrepancy in the values of the respective quantities was observed to occur in the range of low heat loads. Tests conducted by using the standard channels found in reactor control and protection, heat monitoring, and energy release monitoring systems revealed that the temperature difference along the channel height is analogous in all cases (although slight differences in the absolute values of the temperature distributions were found). Visual observations of glass pipes and data from experiments conducted with metal pipes indicated that the heat transfer process in a tube with a heat-insulated side wall that occurs during turbulent natural convection is dictated primarily by eddies whose linear scale is close to the inner tube diameter. The discrepancy between the calculated coolant temperature distribution data and data obtained in experiments on existing equipment did not exceed 10% of the temperature difference in the channels in the upper section of a VVER reactor. Figures 3; references 4 (Russian).

Selected Problems in Increasing the Operating Reliability of the Regulator of the Boiler Water Level in the Steam Generator of an AES With a VVER-1000

[Article by V.G. Vysotskiy and N.N. Davidenko, engineers, Kalinin AES; UDC 621.311.25:621.039]

[Abstract] The authors of this study examined selected aspects of the problem of increasing the operating reliability of the boiler water level regulator in the steam generator of a nuclear power plant with a VVER-1000 reactor. Their analysis was based on the flexible feedback system used at the Kalinin AES, in which a type D01 unit of the Kaskad series is used as a differentiator. After analyzing the experience of operating regulators with a correcting signal based on the difference between the temperatures of the hot and cold loops, the authors recommended that it would be advisable to use the generator's electric power as a correcting signal instead. They then proceeded to outline a procedure for conditioning the said correcting signal. This procedure included feeding a normalized current signal of the active electric power to three inputs of a type AO5 adder with three words and then feeding the converted signal to the steam generator's four level regulators. They also recommended feeding a fixed current into the adder to compensate for the fact that the electric power signal lacks a component proportional to the flow rate of steam through the fast-acting atmospheric exhaust station and fast-acting steam dump station [BRU-A and BRU-K]. Because the most frequent cause of level regulator failures is failure of the channels measuring feedwater flow rate, the authors recommended that three sensors be used to measure the said flow rate and that unreliable readings be rejected. Procedures for diagnosing failed sensors by means of comparators were also outlined. To improve the level regulators' operating reliability even further, the authors recommended that transient processes be analyzed before the occurrence of visible failures on unit computer systems. An algorithm and specific computational procedures for doing so were outlined. The proposed algorithm was then used to develop a computer program that was eventually installed in the Kompleks-Uran information computer systems in the Nos. 1 and 2 units at the Kalinin AES. The new program allows operating personnel to receive failure messages in the bottom line of their TV display screens. Operation of the program has demonstrated that both faults and soft failures of the boiler water level regulator may be discovered between 1 minute and 5 hours before a fault (soft failure) becomes explicit. Figures 4; references 3 (Russian).

Floating Modular Units for Erecting Nuclear Power Facilities

[Article by K.Z. Galustov and K.A. Abadzhyan, candidates of technical sciences, and A.B. Pavlov, engineer, Gidroproyekt Scientific Research Station, and I.I. Rylov, candidate of technical sciences, Orgenergostroy All-Union Association: UDC 621.311.25: 621.039.69.057.1]

[Abstract] Recent integrated R&D conducted jointly by a number of institutes has confirmed the fact that the use of floating modular units when constructing various facilities, including nuclear power plants, can increase construction efficiency dramatically. The following were among the specific research findings. The center of gravity of the modular units should be as low as possible to keep the unit stable. It is best that the axes of the pontoons' longitudinal and transverse bulkheads coincide with the axes of the unit's walls and partitions. The foundations of the floating modular units should be made in the form of honeycomb reinforced concrete structures and should be combined with a double bottom if the modular units do not contain sealed compartments on their first story. Massive equipment to be used in the modular units should be joined to their bearing structures and secured so as to keep inertial forces to a minimum. The bottom and sides of the modular units

should be made entirely of monolithic reinforced concrete and protected with a metal facing or special coating up to the level where they might make contact with the water while rolling. The height of the floating modular units should be kept as close to the water surface as possible to reduce any sail effect. Special housing enclosures and ice reinforcement should be used when transporting the floating modular units under Arctic Sea conditions. The floating modular units may be designed in one of two ways. The units may be buoyant in and of themselves, or artificial means may be used to keep them afloat. The latter should be equipped with permanent or removable pontoons that are designed as a single whole together with the floating modular unit. Reinforced honeycomb structures make the best permanent pontoons, and metal is the preferred material for removable pontoons. Several different versions of floating modular units have been developed. The version based on the "load-on-a-barge" principle is simple but has a number of shortcomings, including inadequate seaworthiness characteristics. The "single modular unit" principle is preferable; the advantages of the "single entity" principle become increasingly apparent as the mass and size characteristics of the given modular unit are increased. The principles of using floating modular units to construct a nuclear power plant are illustrated by way of the example of the construction of a floating nuclear power plant with an electrical capacity of 2,000 MW and about 20 buildings, including two reactor rooms equipped with VVER-1000 reactors and two turbine buildings. Expert economic estimates have indicated that using the floating modular unit approach to constructing a nuclear power plant with a VVER-1000 reactor will reduce the required capital investments by 37%. The same estimates indicated that the capital investments required to construct an ATETs-150 would be reduced by 27%. Figures 5; references 3 (Russian).

A Safe and Ecologically Acceptable Nuclear Fuel Cycle

[Article by M.F. Troyanov, doctor of technical sciences and professor, and V.M. Murogov, doctor of technical sciences, Power Engineering Physics Institute; UDC 621.039]

[Abstract] One way of making the nuclear fuel cycle safer and more acceptable from an ecological standpoint is to switch to the use of what has been termed a mixed fuel cycle involving the use of natural reserves of uranium (uranium 235 and 238) and thorium and the artificial fissioning isotopes ^{239}Pu and ^{233}U in slow and fast reactors. This will solve two problems simultaneously. First, it will increase reactors' internal inherent safety. Second, it will virtually eliminate higher transuranium and transplutonium isotopes in the irradiated fuel of the said reactors. Introducing a mixed uranium-plutonium-thorium fuel cycle will not only significantly improve the technical and economic indicators of

nuclear power plants with slow and fast reactors alike, but it will also lay the foundation for a nuclear future that is free from the accumulation of excessive quantities of plutonium and other transuranium elements, which are currently posing significant problems in the area of radwaste disposal. What is being proposed is a flexible mixed cycle that will make it possible to accomplish three things simultaneously: 1) optimize the plutonium balance; 2) create a new generation of light-water reactors with a qualitatively new safety level; and 3) use fast reactors to burn plutonium and other antinoids and to recover ^{233}U. When necessary, the thorium breeding region in these fast reactors can be replaced by a uranium region for intensive recovery of plutonium for purposes of supplying fuel for the nuclear power generation process. ^{233}U yields far lower amounts of primary fission products than do ^{235}U and plutonium, and thorium has several important advantages over uranium and uranium-plutonium fuels. The two major drawbacks of thorium reactors (namely, protactinium poisoning and accumulation of ^{232}U in ^{233}U) can both be dealt with effectively. Using thorium in the breeding regions of fast (type BN) reactors will significantly improve their safety as well. Nuclear fuel based on ^{233}U may also find application in space and "self-contained" nuclear power plants. The use of ^{233}U and thorium in modular-type high-temperature gas-cooled reactors is also quite promising. The concept of a mixed uranium-thorium-plutonium fuel cycle and reactor units is not meant to negate the progress that has been made to date in Soviet nuclear power engineering. Rather, it is intended to expand the domestic nuclear reactor base. The long-range program for R&D related to assimilating a thorium-based fuel cycle is geared toward the use of both VVER- and BN-type reactors. An important component of projected thorium-based nuclear fuel cycles will be to reprocess the spent fuel of VVER reactors, which contain large amounts of ^{232}U in ^{233}U and ^{231}Pa. Refabrication of the said fuel should occur at enterprises designed to reprocess spent fuel by using remote technologies. An existing radiochemical plant would be feasible for such purposes. The operating modes of BN and VVER reactors with a thorium-based fuel cycle have already been worked out. A high-selectivity technique for extracting ^{233}U from irradiated metallic thorium has already been developed and tested, as have methods for attracting and concentrating ^{231}Pa. Preliminary technical and economic calculations of the proposed fuel cycle have also been made. One of the main problems remaining is that of the radiochemical processing of spent fuel. Another critical problem is that of selecting the fuel compositions for all types of reactors. Metal-ceramic composites currently seem promising, especially in the case where type PuO_2-Th fuels are being considered. References 6: 2 Russian, 4 Western.

Earthquake Protection Function of AES Units

[Article by G.I. Litinskiy, candidate of technical sciences, MP IVIKS [not further identified]; UDC 621.311.25:621.039.550.349.2.621.3]

[Abstract] The survivability of automated technological systems during earthquakes is determined on the strength and rigidity of the system's structures and equipment on the one hand and on the operation of the system's control system (one of the responsibilities of which is to protect the automated technological system against earthquakes) on the other. The task of providing earthquake protection to control facilities entails detecting seismic activity, assessing the degree of its threat to the automated technological system, and switching the control object over to a safe regimen when some set threshold seismic activity levels has been exceeded. At nuclear power plants the function of earthquake protection has traditionally involved the feeding of a seismic acceleration sensor to a comparator and activating the reactor's emergency protection when some threshold acceleration value is exceeded. The electromagnets holding the control rods are deenergized, and the rods begin to drop under their own weight. In the lower position, the rods stop a chain reaction. A trio of measuring channels is used for the earthquake protection function: the emergency protection is activated when the specified seismic acceleration level is exceeded in two of the three channels. This algorithm for operation of the earthquake protection function has several important flaws related to 1) timely detection of seismic activity and 2) the scope of the set of emergency actions that can be taken when an earthquake activating the emergency protection has been detected. Reactor earthquake protection systems are currently designed so that plants continue to operate when a design earthquake has been detected but stop and remain in their safety state when an earthquake stronger than a design earthquake but weaker than a maximum design earthquake has been detected. Designers of reactor control systems have no way of estimating the risk of an earthquake from the appearance of seismic activity as measured on the MSK-64, Mercalli, or other scales based on analogous principles. The dangerous accelerations that develop after a seismic wave persist for tenths of a second, whereas 3 to 4 seconds may be required to activate an automatic reactor protection system and drop the control rods. Locating additional (a diagram illustrating the placement of 25 such sensors is provided) acceleration sensors about 30 km away from nuclear power plants in all directions would improve the advance warning system and provide more response time. The author of this article proposes a series of equipment for communication between reactor control systems and remote seismic stations. He then proceeds to propose an earthquake protection function and algorithms for estimating the degree of risk posed by a seismic wave. Specifically, he presents 10 formulas that are intended to serve as the knowledge base of an expert system to recognize the degree of risk of an earthquake. The values obtained from the said formulas are intended to be supplemented by consideration of a variety of other factors. Included among these factors are recognition of the fact that vertical vibrations are less dangerous than horizontal and the fact that readings obtained from sensors located on the seismic lens will be somewhat elevated. The knowledge base will also be designed to differentiate noise that is not seismic in nature (mine explosions, supersonic aircraft, etc.). The earthquake protection function and algorithm presented are also recommended for use with chemical plants, electric power plants, and pipeline and railroad transport systems. Figure 1: references 7 (Russian).

Investigation of the Transient Processes in a System To Control the Feedwater Level in the Steam Generator of a VVER-1000 Reactor Unit

[Article by Ye.V. Bogdanova and V.I. Pizhankov, engineers, and G.V. Yevstratov, A.S. Ponomarev, and E.G. Chayka, candidates of technical Sciences, Kharkov Polytechnic Institute and Kharkov Department, AEP (not further identified); UDC 621.311.25:621.039.62-5]

[Abstract] The authors of this study examined the transient processes occurring in the feedwater level control system of a nuclear power plant unit with a VVER-1000 reactor. A mathematical model of the steam generator was constructed based on the condition of preservation of the balance between water influx and steam output with an allowance for changes in water level due to "swelling." The equation system derived was solved on a YeS-1061 computer by using a special package for modeling continuous processes that is geared toward analyzing the motion of objects describable in terms of ordinary differential equations. Optimal values of the following parameters were obtained: balance of water influx and steam output, the same balance but with an allowance for "swelling," the gain characterizing the "swelling," and the feedback time constant and gain for each of the three positions occurring in accordance with the law of a two-position relay with an insensitivity zone. The program package was used to perform numerical calculations for the cases where the "swelling" of the control object's water level was increased by 30% and for a 50% load shedding. The studies conducted showed that the number of switchings of the generator regulator within a specified time interval depends both on the components of the vector of the regulator's adjustment and on the shedding of the steam generator's load. The computation results showed that the proposed technique of control by corresponding selection of optimal adjustments is at least as good as existing experimental data and previously published simulated data on two counts: from the standpoint of the duration of the transient processes involved and from the standpoint of the maximum deviation of the feedwater level. The studies described herein thus demonstrated that existing three-pulse generator regulators can provide entirely satisfactory feedwater level regulation provided that optimal adjustment parameters are selected and that actuators with a lower time constant (in other words, actuators whose speed surpasses that of the drive regulating the steam generator's feed valve) are used. (Figures 2; references 6 (Russian).

Layout Decisions for Underground AES

[Article by O.V. Koitun and B.K. Pergamenshchik,
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shev, and Yu.B. Nikolayev and P.D. Stepanov, VNI-
INTPI, USSR Gosstroy; UDC 621.311.25:621.
039.624.1]

[Abstract] A study examined possible layouts for under-
ground nuclear power plants with VVER-1000 reactors.
The study was based on the assumption that the nuclear
power plant was being erected under conditions of a
ravine relief in rock with a hardness coefficient of 10 to
12 and at least 40 to 60 m of soil above the vault head.
The standard design of nuclear power plants with
VVER-1000 reactors as developed by the institute Atom-
proyekt was taken as a starting prototype. The generally
accepted dimensions for construction of underground
hydroelectric generating stations (span, 33.5 m; height,
64.6 m; length, 492 m) were reduced in an effort to
improve the stability of the underground construction
sites. It was decided that the distance between chamber
workings would be no less than the sum of the spans of
two adjacent workings. The first of three versions of the
layout of the compartments of the pressurized area of the
reactor room was a vertical chamber working analogous
to the shape of the pressurized area of nuclear power
plants with VVER-1000 reactors, with the reactor
located in the center of a chamber in the form of a
reinforced concrete shaft about 23 m high and 10.8 m in
diameter. The second version was a horizontal chamber
working in which the equipment of the plant's primary
loop was located in a chamber with a span of 26 m, a
height of 47.2 m, and a length of 76 m. The third layout
consisted of disconnected horizontal chamber workings.
According to the latter layout, the equipment of the
primary loop was located in three parallel horizontal
chamber workings. The central working (span, 10 m;
length 45.6 m) included the reactor shaft, holding pond,
and refueling shaft. The main shortcoming of the first
version was that the large diameter and height of the
chamber working required special measures to coun-
teract the physicomechanical characteristics of the rock
mass. The main advantage of the second version was that
it allowed for the possibility of locating two or more
plant units in one chamber by lengthening the chamber
through the use of massive reinforced concrete protec-
tive walls designed to withstand emergency pressures.
The most reliable (from a safety standpoint) version was
the third version, which allows for the possibility of
locating the reactor, steam generators, main circulating
pump, and emergency systems in separate chambers.
The main drawbacks of this layout version are as follows:
1) the significant lengthening of the primary loop and
resultant need to increase the capacity of the main
circulating pump; 2) the increased construction cost; 3)
the reduction in the overall reliability of the under-
ground nuclear power plant; 4) the need to erect con-
necting tunnels between the reactor and steam generator
boxes; 5) the inconvenience of installing equipment
(especially the inconvenience of installing a reactor
under the cramped conditions of small chambers); and 6)
the overall complication of the underground excavation
work required to open the cross sections of the working
faces. The problems of water supply, ventilation, and
configuration of the auxiliary reactor room systems were
left to future analyses. Figures 3; references 2 (Russian).

The Manufacture of Large Thick Sheet Blanks by the Forging Method

[Article by G.A. Pimenov, candidate of technical sci-
ences, G.A. Kostyukov, P.S. Ryabov, V.D. Rogal, and
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Machine Building Technology Scientific Production
Association, Snergomashspetsstal Plant, and Atommash
Production Association; UDC 621.73.04]

[Abstract] Currently used rolling processes cannot be
used to produce large one-piece thick sheet blanks more
than 4,800 mm wide. Such blanks must instead be
produced by welding two or more blanks together. The
Atommash manufactured 10 sheet blanks measuring
5,500 x 5,500 x 280 mm by using the combined rolling
and welding technique. Only two of the 10 blanks were
deemed suitable for use in the bottom of a VVER-1000
reactor. In view of these facts, a study was conducted to
develop and introduce an integrated process for manu-
facturing large one-piece forged blanks measuring 5,500
x 5,500 x 280 mm for eventual use in the bottoms of
VVER-1000 reactors made of 15Cr2NiMoVN steel. To
eliminate the problems encountered in previous
attempts to manufacture such large one-piece blanks by
using forging techniques, a manufacturing process was
developed that combined drifting, press broaching, roll
forging, and reaming. A working process for forging a
unique tube blank was developed in accordance with
which standard blanks were forged from a 145-ton ingot
(15Cr2MoNiVN) in 7 to 8 heating cycles. The process
had a utilization factor of 67% and could be used to
produce tube-shaped forgings up to 6,000 mm long. A
process for straightening a shell into a sheet was then
developed to produce a flat blank from the tube blanks.
The new process for producing thick sheet blanks from
tube blanks was introduced at the Atommash Production
Association. It consists of the following operations:
intake inspection, machining the ends of the blanks,
welding the eyes together so that the shell can be trans-
ported, vertical turning and boring along the inner and
outer surfaces, ultrasound flaw detection, cutting out a
test sector and grips for transport, heating to straighten
the shell into a sheet, straightening the shell into a sheet
by using a set of changeable plates, and heat treatment.
The new process results in steel with a comparatively
fine-grained structure (4 to 5 points) and with mechan-
ical properties that meet specification requirements.
Ultrasound inspection also confirmed that the steel was

of a quality conforming to specification requirements. Despite its obvious advantages, the new forging process for producing thick sheets also has the following disadvantages: 1) given the limitations of existing equipment, it cannot be used to produce large-diameter tube blanks longer than 5.5 m; 2) a sector must be cut out of the tube blanks to allow for tool placement, which reduces the metal utilization factor of the process; and 3) a large number of passes are required to straighten the shells into sheets. The new process has, however, made it possible to produce one-piece sheets with the dimensions and quality required for use in VVER-1000 reactors. When compared with the conventional rolling-and-welding process, the new process is less labor intensive (by a factor of 4.6) and requires 10 to 15% less metal. It is also much more reliable. Figures 5, tables 2; references 3 (Russian).

Assessment of Main Trends in the Development of Turbine Control Systems at AES With POAT KhTZ Turbines

[Article by Ye.A. Golovach, candidate of technical sciences, Central Boiler-Turbine Scientific Research and Design Institute imeni I.I. Polzunov; UDC 621.165.62-5]

[Abstract] POAT KhTZ turbines for AES are equipped with automated turbine control systems whose electronic portion was developed at the Monolit Production Association. The automated turbine control system was first tested on the K-500-5.9/25 turbine of the Novovoronezh AES in the mid-seventies and has been improved many times and in many ways since that time. One of main components of the automated turbine control system is its electrohydraulic control system. It has also been the object of continuing research studies and modifications. The electrohydraulic control system was developed to meet the requirements stipulated for power plant equipment regarding maintaining rotor rotation frequencies, turbine power, and steam generator pressure within specified ranges under normal and emergency operating modes. The electrohydraulic control system switches from operating mode to operating mode in accordance with an established hierarchy; executes control algorithms corresponding to standard and emergency regimens through a single control channel; and has the structure of an electrohydraulic servo drive. It has been subjected to numerous mathematical, physical modeling, and experimental studies at the Novovoronezh, Kalinin, Ignalina, and Zaporozhye AES and at several scientific research institutes and scientific production associations and has performed the tasks expected of it reliably. The immediate plans to further improve the electrohydraulic control system include work to accomplish the following: develop proportional-action control slide valves to be placed behind the moisture separator/reheaters with intermediate positions for partial loads; develop recommendations to improve the electrohydraulic control system from the standpoint of its control algorithms, adjustment parameters, and reliability; and develop new methods of diagnosing the system. Work is also under way to optimize the electrohydraulic control system's interaction with other nuclear power plant systems and equipment, including the systems to control and adjust steam temperature beyond the moisture separator/reheater, the pressure regulator of the fast-acting steam dump station, and the condensate-feed path controllers. Specifically, a moisture separator/reheater control algorithm was developed that was later later used to develop control systems for K-1000-5.9/25-2 and K-750-6.4/50 turbines and a temperature control system for K-1000-5.9/25 turbines. The studies conducted in relation to the algorithms currently in place to use the fast-acting steam dump station to control steam generator pressure in units with VVER-1000 reactors has confirmed that these algorithms are satisfactory. The research did not, however, contraindicate further research to reduce pressure overshoots in the steam generator in order to eliminate the possibility of activation of the fast-acting atmospheric exhaust station and to improve the steam generator's overall reliability. Research on the new condensate-feed path controllers that the Monolit Production Association developed on a unified component base confirmed that the new controllers are superior to their predecessors in many ways. It is now critical that further work be done to incorporate the moisture separator/reheater, fast-acting steam dump station, and fast-acting steam dump station into an expanded microprocessor-based electrohydraulic control system operating on a unified component base. Other areas for future R&D include optimization of the electrohydraulic control system's interaction with neutron power controllers and the controllers of steam pressure beyond the moisture separator/reheaters and in the steam generators by means of fast-acting steam dump stations. Table 1; references 13 (Russian).

Ways of Improving AES Turbine Systems

[Article by M.A. Virchenko, candidate of technical sciences, Yu.F. Kosyak, doctor of technical sciences, Ye.V. Levchenko, engineer, B.A. Arkadyev and V.P. Sukhinin, doctors of technical sciences, and V.A. Paley and V.N. Galatsan, candidates of technical sciences, Turboatom Scientific Production Association; UDC 621.165.621.311.25:621.039]

[Abstract] Despite the dramatic slowdown of Soviet development of turbine equipment for use at nuclear power plants, the Turboatom Scientific Production Association has continued its research and design work related to improving AES turbine systems. The authors of this article review the association's recent work in the areas of improving AES turbine system reliability, economy, heating circuits and auxiliary equipment, automation and diagnosis, and modernization. In the

area of reliability, the Turboatom Scientific Production Association has developed welded-forged rotors that are distinguished by their high dynamic stability and has done a great deal of experimental and theoretical work in the area of improving turbine blading reliability. In the area of improving turbine system economy, the association has conducted extensive research to improve the gas dynamics of turbine flow paths and to improve the existing system of cleaning coolant water and condenser pipes. In the area of automation and diagnosis, the Turboatom Scientific Production Association collaborated with the Monolit Production Association to develop the ASUT-550P automated turbine control system, which is a world-class system combining logical automated management, automatic control, and automatic system adjustment in an interactive mode. The Turboatom Scientific Production Association is currently conducting extensive R&D directed toward developing a family of turbine systems with capacities ranging from 1,000 to 1,300 MW. The new turbine systems are distinguished by the following: a new combination high- and medium-pressure section with separate high- and medium-pressure portions; a standard (i.e., standard within the new series) low-pressure section flow path with a blade 1,650 mm long in the final stage; a newly designed structure for the separation of intermediate steam superheater systems; design decisions that have made it possible to reduce the size of the turbine building; a microprocessor-based automated turbine control system; a high-speed turbine pump feed unit that includes an exhaust to the main turbine's condenser; and a fast-acting steam dump station [BRU-K] that is connected to the control system and that is a part of the automated turbine control system so as to ensure all required transient processes in the turbine system. Figures 9; references 9 (Russian).

Using Local Loam for Radiative Waste Vitrification

[Article by F.A. Lifanov, S.V. Stefanovskiy, T.N. Lashchenova, A.P. Kobelev, Radon Scientific Production Association, Moscow; UDC 666.11.01:621.039.0048]

[Abstract] Radioactive waste (RAO) decontamination by the vitrification method which involves production of glass from a charge containing radioactive waste salts or oxides and fluxing additives is discussed; in vitrifying sodium containing radioactive waste, the fluxing additive must be nonalkaline as well as inexpensive and easily available. The use of local loams which meet these requirements is described and the effect of the quartz sand substitution with loam in borosilicate glass charge (to immobilize various types of radioactive waste) on the glass properties, i.e., the charge plasticity Atterberg number, the complete glass melting duration, the viscosity and electric resistivity of the glass body at a 1.150°C temperature, and the rate of ^{137}Cs radionuclide leaching on the 28th day of contact with water (by the IAEA method), is investigated. The study demonstrates that substitution of up to 50-70% of silica sand with loam for immobilizing waste from research reactors and pressure-tube nuclear power plant reactors and up to 80% of quartz sand for immobilizing waste from water-moderated water-cooled power plant reactors makes it possible to ensure optimum charge and glass properties and reliably insulate radioactive waster from the biosphere. The findings are being used at the "Radon" Scientific Production Association in Moscow for vitrifying all types of radioactive waste. Tables 4; references 5.

Investigation of Erosion-Corrosion Properties of Structural Materials and Protective Coats

[Article by I.A. Shalobasov, B.Ya. Ivnitskiy, V.A. Mikhaylov, A.Ye. Luzganov, VNIIAM; UDC 621.4.002.5.669.15]

[Abstract] Studies aimed at researching, examining, and evaluating the erosion-corrosion resistance of today's structural materials and protective coats used in power engineering are described. These studies are intended to increase the reliability and service life of power generating equipment and are carried out at the VNIIAM using an "Eroziya" test bench which simulates cavitation wear in a feedwater flow in a slotted channel. The cavitation number κ is used as the noncavity flow condition criterion. The mean wear rate of the MKS alloy (both heat treated and regular), ChN-36 and ChN-30 pig iron, and steels 20, 20Kh13, 04Kh21N6M2D in cavity and noncavity conditions is examined and the effect of thermal cycling around the phase transition point on the wear rate of steels 20, 14Kh17N2, and 25Kh1MF is assessed. The wear rate of titanium and titanium and boron nitride protective coats of varying thickness on the base from steel 30Kh13 is summarized. The studies show that the MKS alloy and ChN-36 and ChN-30 pig iron have a good corrosion resistance and that thermal cycling temperatures and numbers of cycles of steels 20, 14Kh17N2, and 25Kh1MF can be optimized. Titanium-titanium nitride coats are recommended for implementation. In addition, tests of powder composites and protective coats developed at the Belarus Republican Scientific Production Association of Powder Metallurgy are reported; the tests demonstrate the expediency of using thin coats deposited by the vacuum method and show that with respect to their erosion and corrosion resistance, they can be arranged in the following order: 12Kh18N10T, TiN, and Cr+CrN. In other words, the corrosion and erosion resistance tests reveal the following promising coats: titanium carbide, combined Cr+CrN coats, titanium nitride, and titanium carbonitride. Tables 5; references 3

One Aspect of Lengthening the Refueling Cycle of VVER-1000 Reactors

[Article by A.A. Serdobintsev, candidate of technical sciences, Saratov Polytechnic Institute; UDC 621.311.25:621.039]

[Abstract] The Podolsk Plant imeni S. Ordzhonikidze and the Scientific Production Association of the All-Union Boiler and Turbine Scientific Research, Planning, and Design Institute imeni I.I. Polzunov have jointly developed a new type of saturated-steam steam generator. The new generator features a vertical configuration and has a separate economizer section. This economizer makes the steam generator unit especially "sensitive" to changes in feedwater temperature and makes it possible to increase the mean logarithmic temperature rate-of-rise, which in turn improves the heat transfer process. The said reduction in feedwater temperature also has a direct effect on the temperature of the coolant at the inlet to the reactor and thus on its average temperature throughout the core. The horizontal-type steam generators with which VVER-1000 and VVER-440 are currently equipped do not have this type of economizer. The author of this article presents a series of calculations demonstrating that using the new vertical saturated-steam steam generator with an economizer makes it possible to extend the refueling cycle of a VVER-1000 reactor by 6 days as compared to when a horizontal-type steam generator without an economizer is used. His calculations further indicate that the pressure of the steam generated in a vertical steam generator drops by an average of only 0.7% when each high-pressure heater is disconnected as opposed to the 2% drop that occurs in steam generators without economizers. Furthermore, the 6-day extension of a VVER-1000 reactor's refueling cycle that is achieved by using the new vertical steam generator plus economizer results in an increase of 4.5 million kWh, which is ninefold more electric power than is obtained when a horizontal-type steam generator is used. Figures 3; references 5 (Russian).

The Experience of Redesigning Radial Bearings for K-1000-60/3000 Turbines for AES

[Article by N.P. Yegorov, I.S. Yurchenko, and I.A. Kovalev, candidates of technical sciences, and N.V. Cherkasov and S.V. Prikhodchenko, engineers, Central Boiler-Turbine Scientific Research and Design Institute imeni I.I. Polzunov Scientific Production Association, Leningrad Metal Plant imeni 22nd CPSU Congress Production Association, and Kharkov AES; UDC 621.165.621.822]

[Abstract] The Central Boiler-Turbine Scientific Research and Design Institute imeni I.I. Polzunov Scientific Production Association created stands that make it possible to research the characteristics of radial bearings measuring 240 to 750 mm within a broad range of shaft rotation frequencies and specific loads. On the basis of results obtained from studies conducted on the said stands, the Leningrad Metal Plant imeni 22nd CPSU Congress Production Association developed a new design for a radial sleeve bearing in which oil is fed from the side of the initial formation of the hydrodynamic wedge in the lower half of the bearing line. When compared with a conventional radial sleeve bearing (specifically, a radial elliptical bearing 600 mm in diameter), the new design makes it possible to reduce friction-induced power losses from 850 to 600 kW and to reduce oil consumption from 900 to 600 l/min (thanks to the elimination of end oil leaks in the upper half of the bearing liner). The new bearings were used in K-800-240-3 steam turbines at the Zaporozhye GRES and in K-1200-240 turbines at the Kostroma GRES. The Central Boiler-Turbine Scientific Research and Design Institute imeni I.I. Polzunov Scientific Production Association and Leningrad Metal Plant imeni 22nd CPSU Congress Production conducted joint studies in an effort to further improve the new bearings. Additional research was then constructed to further modify the new bearings so that they would be suitable for use with less flammable synthetic oils (specifically, the refractory oil OMTI). The bearings' vertical and horizontal oil gaps were enlarged, and access paths to permit better oil drainage were fashioned in their liners. These steps resulted in a reduction of the temperature of the babbitt in the radial sleeve bearings of 6 to 8°C. In studies examining the use of the newly redesigned bearings on K-1000-60/3000 turbines at the Yuzhno-Ukrainsk AES, the temperature of the babbitt in the bearings did not exceed 76°, and the total losses to friction did not exceed 3,400 kW at an oil flow rate of 4,050 l/min. Figure 1, tables 3; references 2 (Russian).

Automated Turbine System Design Subsystem

[Article by V.B. Sergeyeva and V.Yu. Ioffe (deceased), engineers, Central Boiler-Turbine Scientific Research and Design Institute imeni I.I. Polzunov Scientific Production Association, and Kharkov Turbine Plant Scientific Production Association; UDC 621.65.62-5.001.2]

[Abstract] The Sekvoyya subsystem is a structural component of the automated steam turbine system design system developed at the Kharkov Turbine Plant's Scientific Production Association. It is intended for use in designing power generation turbine systems in the detail and contractor design stages. The system's software and algorithm set includes two application packages. The first (a design procedure) is intended for use in heat engineering calculations; the second (a service procedure) is a computer graphics package. The design procedure makes it possible to formalize a turbine system in the form of a mathematical model. Algorithms and programs are provided for modeling the turbine flow paths, auxiliary equipment, and structural variations of heat diagrams. The heat engineering application package consists of 10 modules for use in calculating the following: the thermophysical properties of water and steam; the heat balances of turbine systems at TES and AES; a turbine's efficiency throughout each of its stages; steam leaks through end seams and valve stems; and condenser parameters. The computer graphics package contains a program to output the results of different versions of computations in table or graph form; a program for graphic representation of processes of steam expansion in a turbine; and a program to produce schematics of a turbine system's heat circuits. All of the graphic programs are geared toward specific equipment (computers, display terminals, graph plotters). The components and applications of both application packages are discussed in detail. Figures 4, table 1; references 4 (Russian).

Development of New Types of Turbogenerators

[Article by G.A. Bezchastnov, engineer, USSR Ministry of Power and Electrification]

[Abstract] In the period from 1980 to 1987 the USSR electrical industry began producing a unified series of turbogenerators with capacities ranging from 63 to 800 MW with hydrogen and water cooling. The new turbogenerators were smaller and lighter weight but were not significantly better than their predecessors from a performance standpoint. In 1995 the electric power plants under the USSR Ministry of Power and Electrification will no longer produce hydrogen-cooled turbogenerators. Series production of turbogenerators that are cooled entirely by air or fluid will be established in the period between 1990 and 1994. The new turbogenerators, which are totally fire- and explosionproof, will be produced with capacities of 20, 32, 63, and 100 MW (the air-cooled turbogenerators) and 110, 220, 320, and 500 MW (the fluid-cooled turbogenerators). Turbogenerators (capacity, 800 MW) that are cooled entirely by water are already operating successfully at the Perm and Ryazan

GRES. The new turbogenerators, designated TZV and TVM(ng), feature cores and stator windings with increased stability when exposed to vibrations. The new fluid-cooled turbogenerators will not require any complicated oil seals and will be much more efficient than gas-cooled turbogenerators. In their rated power mode, the new TVM(ng) turbogenerators provide a 0.36% gain in efficiency, which means a savings of 1.2 g fuel equivalent for every kilowatt-hour of electricity generated when compared with the TF-100 turbogenerator. The TZV-220 provides analogous fuel savings when compared with the TF-160. The actual fuel savings are even higher because 110- and 220-MW generating station units are generally designed for operation in demand-adaptable modes. The new fluid-cooled turbogenerators thus provide a two- to threefold increase in efficiency. The use of turbogenerators with fluid cooling will also make it possible to reduce the range of turbogenerator capacities required. The need for 160-MW turbogenerators will virtually be eliminated. The new-generation turbogenerators will be equipped with the latest monitoring and diagnostic equipment and will be designed for use with automated control systems. The new turbogenerators should raise the engineering level of electric power plant equipment significantly and improve the reliability of power supply to plant customers. Figures 2.

Construction of Water Storage Power Plants

[Article by G.M. Babayants, candidate of technical sciences, USSR Ministry of Metallurgy, G.A. Markov, doctor of technical sciences, S.A. Chesnokov, candidate of technical sciences, Orgenergostroy, and L.B. Sheynman (deceased); UDC 621.311.624.1]

[Abstract] In many countries including the USSR there has been a trend toward construction of water storage power plants operating as components of unified power systems. At present, 35 countries throughout the world have operating water storage power plants with a total installed generating capacity of 70 million kW. The USSR currently has its 225-MW Kiev GAES (an above-ground power plant), and four units under construction at the Zagorsk GAES (800 kW). Several such facilities are also in the planning stage. Because of the ecological problems associated with the operation of water storage power plants, the possibility of constructing water storage power plants underground has been receiving increasing attention. According to data of American engineers, the costs of erecting an underground power plant in a previously existing cavity or space are about half those of erecting a plant when the space to house it must be excavated. Studies involving several scientific research institutes and the mining department of the USSR Ministry of Metallurgy have been conducted to assess the feasibility of various already-existing underground sites as prospective locations for an underground water storage power plant. One possible site is the mine

imeni Gubkin of the KMArud Combine, which has more than 300 depleted chambers. According to estimates, if a GAES were to be created at the site of the Gubkin mine, the land that would have to be dispossessed would amount to only a seventh of the land that would be dispossessed if an above-ground plant were to be constructed. The underground workings at the Gubkin mine have remained stable without reinforcements for more than 45 years. No instances of complete collapse have been recorded in any of its chambers (which span 30 m, are 55 m long, and 54 m high) in that time. Data provided by the geological service indicates that individual sections of the ledge (8%) are intersected by dikes that represent a possible source of water filtration. The Gubkin mine is in a stable state at the present time. Periodic photographs of the chambers' contour indicates that the deviation of the actual chamber contours from their design state does not exceed 1 to 3 m. In several chambers crumbling of the pillar walls is rather significant and reaches a maximum of 10.5 m. Researchers from two different institutes advise that a 125-m protective zone be established around the construction site as a precaution when explosives are used. A reliable hydraulic link intended for water storage must also be established between the chambers, and measures will have to be taken to remove crushed ore from the chambers as the construction proceeds. The proposals also call for erecting a new underground building measuring 24 x 120 x 50 m for the GAES building. The deposit will be worked in stages so as to recover as much of the ore resources as possible as the water storage space is formed. The details of the construction of the Gubkin GAES are still being worked out and will be worked out with consideration for the impact of the plant's construction on the environment. Figures 2.

Steam-and-Gas Technologies at TES in Ukraine

[Article by N.A. Borisov, engineer, Ukrenergoproyekt]

[Abstract] In the Ukraine construction of new nuclear power plants has ceased; however, money and resources are continuing to be allocated to safeguard nuclear power plants in the aftermath of the Chernobyl accident. The program to develop thermal power generation has also stopped receiving funding. The many ecological problems at thermal electric power plants [TES] remain unsolved. Many TES are in need of immediate reconstruction that would require billions in capital investment. The capacity balance of the Ukraine United Power Generation System is currently critical. The present reserve is between 5 and 7% (versus the design range of 13-14% or the 20-27% reserve required abroad). The system will be further strained by the planned shutdown of the Chernobyl AES in 1995, the 4-7% increase in auxiliary electric power consumption by TES due to stricter gas scrubbing requirements, and the fact that 70% of the primary equipment at electric power plants

throughout the Ukraine will have exhausted its operating life by the year 2000. The only way out of this situation is to essentially retool the entire sector in the next 10 to 15 years by using a qualitatively new engineering base. Given the present status of power machine building, virtually the only available technology for retooling the power generation sector is a method based on gas turbine units operating with a binary cycle as a component of steam-and-gas units with waste-heat boilers. The Ukraine Ministry of Power and Electrification is taking steps to develop gas turbine construction in the republic with participation of a number of industrial sectors. A program has been planned that calls for the reoutfitting of existing TES with steam-powered units by installing gas turbine superstructures. The gas superstructures are to have the operating flexibility required to be able to operate within a wide range of loads including a no-load state, alternating starts and stops, transitions from one operating mode to another, or self-contained operation of the steam power section apart from the gas turbine superstructure. The following four circuits have been deemed the most economical and feasible based on an analysis performed at the All-Union Heat Engineering Institute imeni Dzerzhinskiy: 1) a gas turbine unit based on a recovery replacement scheme; 2) a gas turbine unit involving dumping of the exhaust gases into the boiler; 3) a recovery-type steam-and-gas unit (without after-burning); and 4) a recovery-type steam-and-gas unit with afterburning in a waste-heat boiler. The main advantage of the first scheme is the relative simplicity of transforming the steam power equipment of existing TES into a steam-and-gas unit. The said scheme is preferred when reoutfitting existing TES where the main vessels and general plans are cramped or when low-reaction coals are used as the principal fuel. The second scheme (gas turbine units with dumping of the exhaust gases into a boiler) requires substantial overhaul of existing boilers, including redesign of their heating surfaces. Although this method is more efficient than the first, it requires greater up-front costs for modification of existing facilities and equipment. The third and fourth schemes, which may both be classified under the heading of binary-type steam-and-gas units, are the most efficient and are preferred in newly constructed TES. They may also be used in gas-fired TES. At facilities with a mixed fuel regimen (gas-mazout, gas-solid fuel) it is advisable to consider redesigning the existing section based the first or second schemes.

The Dynamics of Structure and Location of Electric Power Generation at the Turn of the Century

[Article by R.Ye. Mirkovskaya, engineer, and Ya.I Khainson, candidate of technical sciences. Energosetproyekt; UDC 621.31:338]

[Abstract] The recent revamping of the country's entire sociopolitical, social, and economic life has posed a number of new problems with regard to the development of power generation with a regional profile. Another big problem is the enormous efforts that have been directed toward suppressing the development of power engineering and rejecting existing power sources without proposing any viable alternatives. The reality is that by the year 2020, there will only be two power sources that can be counted on: nuclear power and coal (mainly from the Kansk-Achinsk basin). Research has shown that the reduction in electricity output amounting to about 300 billion kWh in the next 10 years will result in economic losses ranging from 200 to 500 billion rubles. The losses resulting from not adding new AES in the European territory of the former USSR will be particularly significant. Five versions of the electric power balance reflecting the dynamics of the development of electricity consumption and the structure of generating capacities have been studied. The research has resulted in seven principal conclusions. The dynamics of electricity use in the territory of the former USSR has been estimated as ranging either between 2,000 and 2,700 or 2,200 and 3,000 billion kWh, during which time most new industrial facilities will continue to be located in the European territory of the former USSR. Production of electric power in these European territories should be based on the use of nuclear fuel and the resources of the eastern regions of the former USSR (mainly coal and water power), with gas being used primarily to produce heat. Scientific-technical progress in the production of electric power will hinge on the following: creation of improved and fundamentally new types of AES meeting stricter safety requirements, creating fundamentally new technologies for using low-grade solid fuels with improved ecological characteristics, large-scale use of different types of steam-and-gas power plants based on high-temperature gas turbines, and creation of new types of power equipment using renewable energy resources (mainly hydroelectric generating units at small GES). Analysis of all five of the aforementioned power balance scenarios indicates that nuclear fuel will still be the most economically feasible energy source in the period under consideratio‾ for most of the territories of the former USSR, but i should be used in a well-reasoned combination with locally available energy sources. In the said period, fossil fuel-fired power plants will account for 70% of all electricity generated, and the role of AES in power production should be raised first from 10 to 15% and eventually from 15 to 25%. Efforts to find a way to relocate AES from densely populated areas to more remote areas must be continued so that by the year 2015 between 20 and 32 million kW of capacity will be concentrated in "clusters" of two to three power plants each. The traditional practice of locating AES in the European portion of the former USSR is no longer possible because of the population density of the said area. The focus must therefore be shifted to finding ways of transporting power produced in remote areas, particularly to the Arkhangelsk and Vologda oblasts and possibly to the Republic of Komi. Figures 2, tables 2

An Investigation of the Effect of Process Factors on the Emission of Nitrogen and Sulfur Oxides During the Burning of Podmoskovsk Coal in a Circulating Fluidized Bed

[Article by K.A. Suleymenov, Ye.K. Sagitayev, P.T. Saylaubenkov, and B.K. Mukanov, Kazakh Power Engineering Scientific Research Institute, Alma-Ata; UDC 662.642.521.181]

[Abstract] A laboratory unit and an enlarged bench with a circulating fluidized bed were created at the Kazakh Power Engineering Scientific Research Institute for use in investigating the process of burning low-grade coal in a circulating fluidized bed. The primary objective of the studies was to determine the effect that process factors have on nitrogen and sulfur emissions as the coal is burned. The bench unit included a furnace in the form of a rectangular chamber measuring 0.49×0.49 m^2 in the lower section, 0.70×0.70 m^2 in the upper section, and 8.0 m in height. Also included in the experimental unit were bins for the inert matter, limestone, and coal; an air heater; a burner; a heat exchanger; feeders; screw conveyers; a cyclone dust trap; an exhaust gas fan; and a smokestack. Like the bench unit, the laboratory unit contained the various sections and subassemblies characteristic of industrial furnaces. The laboratory unit was capable of providing fuel flow rates of up to 60 kg/h and accommodating fuel particles up to 0.01 m in size. Both the bench and laboratory units were used to study the burning of Podmoskovsk coal with and without limestone additives. Coal particles up to 7×10^{-3} m and limestone particles up to 10^{-3} and 2.5×10 m in size were used. In the studies performed on both units, the concentration of SO$_2$ was directly proportional to the temperature of the fluidized bed. The SO$_2$ concentration was somewhat higher on the laboratory unit than on the bench unit; this difference was explained by the fact that the time for which the stack gases were in contact with the active ash sorbents was greater on the bench unit. An extremal dependence of the degree to which sulfur dioxide was trapped by the limestone was found. The maximum η_{SO_2} occurred when the bed's temperature was between 840 and 860°C. Temperature changes in either direction resulted in a reduction in the degree of SO$_2$ trapping. As the excess of air increased, the η_{SO_2} increased to a plateau value and then remained constant. The measurements taken of the nitrogen oxide concentration demonstrated that the emission of NO$_x$ depends on the fraction of primary air, the temperature of the bed, and the excess of air at the furnace's outlet. The dependence of NO$_x$ emission on the air excess was also extremal in nature, with the maximum nitrogen oxide concentration occurring when $\alpha = 1.2$ to 1.3. The reduced nitrogen oxide concentration level was linked to two-stage burning. Increasing the fraction of primary air resulted in an increase in the nitrogen oxide concentration, and increasing the bed temperature resulted in a directly proportional increase in the amount of NO$_x$ formed. The rate of change in NO$_x$ concentration as a function of temperature was found to amount to 1.2 mg/°C. The studies performed thus confirmed the promise of burning Podmoskovsk coal in circulating fluidized beds. Figures 4; references 2 (Russian).

The Need To Develop Nontraditional Power Generation

[Article by P.P. Bezrukikh, USSR State Fuel and Power Commission; UDC 621.31]

[Abstract] The rebirth of the rural portion of the former USSR will only be possible if a reliable method is found to supply the said areas with heat, hot and cold water, and electricity. This in turn can only be accomplished if new, unconventional methods of power generation are found and developed. Furthermore, the distinctive problems of each particular rural region must be considered. Four points demand special consideration. First, many regions of Russia (the Far North, Far East, Yakutiya, Altay, and parts of Central Russia and the republics of Central Asia and Transcaucasia) are located in areas with decentralized electricity supply. Fuel conservation is the number 1 problem in these regions. Second, even in some areas with a centralized supply of electricity, user disconnections because of the poor condition of the rural power network are not uncommon. The main problem to be solved in these areas is that of storing energy and finding a way to divert excess power into the system. Third, a number of cities have serious ecological problems because of emissions of toxic industrial and boiler wastes into the atmosphere. These areas require an integrated approach to the problems of eliminating the use of small noneconomical boilers and curtailing pollution of the atmosphere. Fourth, all regions of the country are plagued with the problem of heating residences and obtaining hot water for household use. Each and every one of these points must be taken into consideration when developing a plan to use nontraditional power generation methods and equipment. A comparison of three different scenarios for the use of unconventional energy sources indicates that nontraditional renewable energy resources are by far the most promising alternative in many regions that are far removed from centralized electricity sources. In accordance with the scenario that was least favorable for the use of unconventional power sources (when the initial investment for the use of unconventional energy sources must be recouped within 3 years and when the consumption of fuel equivalent is on a par with the countrywide average (i.e., 325 g/kWh)), when the installed capacity of the power plant is used for 2,500 hours and the cost of fuel equivalent is 1,000 rubles per ton, the limiting capital investments in order for nontraditional power generation to be feasible is

1,500 rubles/kW. In the scenario that was most conducive to the use of alternative sources (i.e., given the typical costs of operating a plant with the least economical diesel units), the limiting specific capital investment may even exceed 3,000 rubles/kW. In the third scenario, the limiting specific capital investment would be about 2,800 rubles/kW. Alternative energy sources will become even more economically feasible as the cost of oil and diesel fuel continues to rise. Tables 3.

Development and Production of New Types of Turbogenerators

[Article by Ya.B. Danilevich, doctor of technical sciences, All-Union Scientific Research Institute of Electric Machine Building]

[Abstract] Because of the need to modernize currently manufactured reactors, no development of new AES is anticipated over the next few years. Consequently, it is not anticipated that any new high-power turbogenerators will be created or that production of turbogenerators with capacities of 1,000 MW or more will be expanded. Instead, most of the emphasis will be placed on turbogenerators with capacities of 220 to 800 MW for coal- and natural gas-fired TES and on low-power generators that can be used with energy-saving equipment and powered by nontraditional energy sources. A unified series of turbogenerators with capacities ranging from 63 to 800 MW are now being manufactured, tested, and readied for series production. Turbogenerators with capacities of 63 and 110 MW are being manufactured by the Sibelektrotyazhmash Production Association in Novosibirsk; turbogenerators with capacities of 165, 220, 320, 500, and 800 MW are now being manufactured by the Elektrostal LPEO, and a 500-MW turbogenerator is being manufactured at the Sibelektrotyazhmash Production Association. The 160-MW TVV-165-2Ye and 800-MW TVV-800-2Ye turbogenerators are now the most widely used of all turbogenerators in the TVV series, which have water cooling of the stator winding and a hydrogen-filled casing. Type TZV turbogenerators, which are completely water cooled, have been operating successfully at the Ryazan and Perm GRES for a number of years now. They have a capacity of 800 MW and a rotation frequency of 3,000 rpm and are completely fire- and explosionproof. In the past few years there has also been renewed interest in turbogenerators with an air cooling system. Various collectives are working to develop turbogenerators with air cooling, capacities up to 200 MW, and a rotation frequency of 3,000 rpm. The said generators are intended primarily for operation with gas turbines and for operation as a component in steam-and-gas units. The TAG-115-2UZ turbogenerator (capacity, 115 MW), which was created at the Elektrotyazhmash Plant in Kharkov, is one such turbogenerator. The TV-160-2 (capacity 160 MW), which was created by the Elektrosila Association, is another such

turbine. The ASTG-220-2 asynchronized turbogenerator, which was created by the Elektrotyazhmash Production Association, is now operating successfully at the Burshtyn GRES. It has an active power of 220 MW, a reactive power of 123 Mvar, a rated power factor of 0.95, a voltage of 15.75 kV, and an efficiency of 98.49%. A new asynchronized turbogenerator, the ASTG-800-2, is now being created at the Elektrotyazhmash Production Association. It has an active power of 800 MW, an active power of 600 MW in an extended asynchronous mode, a rated voltage of 24 kV, a power factor of +/-0.8, and an efficiency of 98.8-98.9%. In view of current trends in turbogenerator development, attention must now be shifted to developing diagnosis systems to improve turbogenerator reliability. Diagnostic systems for the TZV-220-2 and TZV-320-2 turbogenerators are especially needed. Figure 1, table 1.

High-Temperature Solar Furnace for Thermophysics Research

[Article by N.V. Karyyev, N.R. Korpeyev, V.V. Shokin, L.L. Krasnov, O.A. Luchev, and N.B. Berezhnaya, Solntse Scientific Production Association, Turkmen SSR Academy of Sciences; UDC 661.311]

[Abstract] High-temperature furnaces have several characteristic features that make them especially promising for use in various manufacturing processes and in thermophysics research. The Solntse Scientific Production Association has created an experimental solar furnace that has been used to conduct research involving high temperatures for a number of years. The new high-temperature furnace consists of a parabolic concentrator 2 m in diameter, a heliostat with a control system, a curtain flow regulator, a temperature measurement section, and a working section. The back of the concentrator has been coated with silver. It has a focal distance of 0.85 m and an aperture of 120°. The heliostat has been mounted from the northern side in an azimuthal-zenith configuration. The control unit permits automatic heliostat tracking with a precision of 5 to 6'. The heliostat has an area of 6.25 m and an average reflectivity of $\rho = 0.8$. Its plane mirrors are mounted on metal frames equipped with three adjusting screws that can be used for precision adjustments. The photoelectric sensor of the furnace's control system is a collimator tube 0.7 m long and 0.06 m in diameter. Four type FSK-2 photoresistors connected in pairs along the azimuthal and zenith channels are built into the back. A diaphragm with a diameter opening of 0.005 m is built into the front. The new furnace's energy characteristics make it possible to conduct experiments over a broad range of temperatures. Because of its obvious advantages over radiation and nonstationary measurement methods, the reflection method is used in determining the monochromatic

normal emissivity of study materials. An EOP-66 precision optical pyrometer with a disappearing filament is also used for precision temperature measurements in the new high-temperature furnace. The experimental unit for investigating the thermophysical properties of materials in the solar furnace consists of an electrical mechanism with a movable rod and specimen holder. The device is mounted coaxially with the solar furnace, and the rod moves at a rate of 1.5 to 5.5 x 10^{-4} m/s. Specimens in the form of tablets 20 to 30 mm in diameter and 10 to 15 mm long may be measured. A manual detailing the procedure for determining the monochromatic normal emissivity, temperature, and breakdown rate of materials subjected to high-intensity radiation fluxes in the new furnace has also been written. Figures 3, references 5 (Russian)

Development of Nuclear Geophysics at the VNIIgeoinformsistem

[Article by A.G. Amurskiy, R.P. Gottikh, A.P. Grumbkov, V.I. Guma, V.N. Dydychkin, Ye.M. Kadisov, S.A. Kantor, V.V. Miller, V.I. Pisotskiy, A.L. Polyachenko, A.I. Spiridonov, and A.S. Shkolnikov; UDC 550.835]

[Abstract] Research in the field of nuclear geophysics has been conducted at the All-Union Scientific Research Institute of Geophysical Information Systems [VNIIgeoinformsistem] for the past decade. The said research has touched upon many of the topics formulated back at the All-Union Scientific Research Institute of Nuclear Geophysics and Geochemistry [VNIIYaGG] and associated with the names F.A. Alekseyev, D.F. Bespalov, B.G. Yerozolimskiy, V.M. Zaporozhets, D.I. Leypunskoy, V.P. Odinokov, N.V. Popov, G.N. Flerov, and Yu.S. Shimelevich among others. Included among the topics that have and continue to be researched are the theory of nuclear well logging, pulsed neutron well logging, multiple-sonde well logging systems, borehole γ-spectrometry, γ-spectrometry analysis of specimens, and nuclear geology. Three new versions of instrumentation for two-sonde pulsed neutron well logging have been developed. The INK-7 is used to study ore and oil and gas wells, whereas the INK-8 and INK-9 are used to study deep thermal oil, gas, and exploratory wells. The detection and telemetry systems of the new instruments are distinguished by their high time resolution. The plant Geofizpribor in Kiev is series-producing the INK-7, has manufactured prototypes of the INK-8, and is preparing a test batch of INK-9. In the area of multiple-sonde neutron-neutron well logging, equipment is being developed featuring position-sensitive neutron counters that are free of many of the shortcomings currently standing in the way of wider-scale use of the multiple-sonde neutron-neutron well logging technique. The main direction of the department of nuclear geophysics in the past few years has been the creation of systems of instruments and techniques for studying the material (elemental, mineralogic, lithologic) make-up of rocks during the well-logging process. Radionuclides (mainly ^{252}Cf) are being used as neutron sources in the said instruments. Another new development, the multifunctional instrument-and-methodology system referred to as the INGK-S, is based on a scintillation γ-spectrometer and high-frequency neutron generator and is intended for use in studying sections of oil and gas wells in order to determine the elemental and mineralogic make-up of their rock, as well as in making detailed lithologic calculations and estimating the nature of the saturation of collectors independently of mineralization of the interstitial waters. Another new development, namely, γ-spectrometry well logging, is based on the high-resolution γ-spectrometry of natural and neutron-activated γ-radiation by using semiconductor Ge detectors. Equipment in the Germes series for use with the said technique has been manufactured and is now undergoing comprehensive laboratory and field tests. Multielement neutron-radiation analysis and reactor neutron activation analysis are two other promising areas being researched at the VNIIgeoinformsistem. The new nuclear-analytic methods mentioned are helping scientists solve a number of basic and applied problems related to petroleum geology. Tables 2; references 4 (Russian)

Wind Energy Throughout the World

[Article by Yu.A. Losyuk, Yu.A. Malevich, and A.Ye. Protskiy, candidates of technical sciences, Belarus Polytechnic Institute; UDC 621.311.24]

[Abstract] Wind has been a source of power for tens of centuries. The remnants of windmills dating from the fourth century B.C. have been discovered in ancient Egypt, and the remnants of similar devices dating from the beginning of the 12th Century have been found in England and France. The depletion of petroleum reserves throughout the world has spawned a worldwide resurgence of interest in wind energy. Throughout the world there has been a marked trend toward increasing the role of the wind energy potential in the overall energy resource balance. The unit capacity of windmills is being increased, and their design is being improved at the same time. The mass of windmills' vanes has been reduced severalfold, and their strength has been increased. Fully automated control of windmills and arrangement of windmills in groups to form wind power installations in the form of stations are two other trends that may be observed throughout the world. The practice of moving wind power plants to the shelf zones of seas is another measure that should make wind power less expensive and more competitive in the future. In the USSR the use of wind energy has been rather modest even though the technically realizable potential of wind energy (i.e., 2 x 10^{10} kW) is dozens of times greater than the installed capacity of all the Soviet Union's operational electric

power plants combined. To date the only wind power plants operational in the USSR have been relatively small (with capacities up to several tens of kilowatts). Wind power installations exist at plants in Astrakhan and Karaganda and the Bashkir affiliate of the Vetroen Scientific Production Association, for example. Scientific research and experiments to develop megawatt-class wind power plants are under way, however. At present, each kilowatt of installed capacity at the small wind power plants operating in the USSR costs 600 to 1,000 rubles, as opposed to current cost of 16 kopecks/kWh for electric power. Figures 3, table 1; references 7 (Western).

The Creation of Geoinformation Banks

[Article by V.A. Vanyushin and S.S. Skotarenko; UDC 519.256:55]

[Abstract] A geoinformation bank is currently being created within the framework of the Geosistema project. The term "geoinformation" here is understood to refer to both geodata and geoknowledge. Empirical geodata in turn refers to data obtained as a result of geological observations and geologicogeophysical and geochemical measurements, whereas empirical geoknowledge refers to models of geological objects derived by special processing of geodata and examination and description of empirical geological objects. Together, empirical geodata and geoknowledge are elements of a complete system that includes theoretical geodata and geoknowledge fixed in the form of concepts. One of the primary objectives of the Geosistema project is the creation and management of computerized bases and banks of geoinformation and the creation and maintenance of a geological management service. The structure of the geoinformation bases of the central state geoinformation bank of the Geosistema will be determined largely by the functions of the state committee for geological (nature) management. One version of how the central system may be structured called for a six-part system. The first part, a geology base, would be divided into three subbases: geology of the country (state), geology of the World Ocean, and geology of foreign countries. Each of these subbases would include cartographic models of the earth's interior (models developed from the standpoints of the fields of geology, geophysics, and geochemistry) and the results of geologicogeophysical and geochemical research conducted under the auspices of state-wide scientific programs (including programs designed to predict catastrophic events). The second element of the central geoinformation bank would be a base of geoinformation related to the mineral and raw material base of the country, the World Ocean, and foreign countries. The third element, namely the scientific-technical information component, would include documents regarding scientific trends in geology based on publications and the results of geological prospecting projects. The fourth element would be devoted to geoecology, the fifth element would be devoted to the raw material market, and the sixth element would deal with the market of services related to geologicogeophysical and geochemical research and projects and
would contain data on domestic and foreign firms and activities. During the period from 1989 to 1991 creation of the various geoinformation bases to be included in the system was financed within the framework of the Geos Interbranch Scientific-Technical Complex. Data (including developing organization and purpose) from about 21 data bases that have been compiled during the said period for inclusion in the state geoinformation bank are presented in table form. Table 1.

Creation and Transport of Water Wheels of High-Power Radial-Axial Hydraulic Turbines

[Article by V.K. Rubtsov and I.S. Veremeyenko, candidate of technical sciences, Turboatom Scientific Production Association; UDC 621.224]

[Abstract] Because the Turboatom Scientific Production Association does not have access to a waterway along which it can ship the water wheels that it manufactures for large hydraulic turbines, it has (over the course of the past 15 years) been forced to develop a set of organizational and technical-engineering measures geared toward solving the problem of transporting large one-piece water wheels with outer diameters of 5.2 to 8 m and weighing as much as 55 to 200 tons. Because rail transport has until recently been the only transportation option available for shipping the water wheels, the efforts to make the water wheels more transportable largely revolved around 1) optimizing their design so as to maximally reduce their overall dimensions and weight and 2) expanding the possibilities of railroad transport. The reserve strength of the materials used to manufacture the water wheels was used to the maximum extent possible, and the practice of installing a packing for the top upper seal ring was adopted. The process used to manufacture one-piece hydraulic turbine water wheels was revamped from start to finish so as to make them optimally transportable. In the area of improving rail transport capabilities, sunken-type cars with an expanded well that could be used to transport water wheels 2,850 to 2,900 mm wide and weighing up to 200 tons were developed. A mixed vehicular-water transport scheme was developed, in accordance with which the water wheels would be transported over land from Kharkov to the shore of the Dneprodzerzhinskoye Water Reservoir. Thanks to the reductions achieved in the water wheels' weight and overall dimensions, it was also possible to work out the world's first system for combined ground-air transport of turbine water wheels. The ground-air transport process was implemented in three stages: transport by motor vehicle from Kharkov to Chuguyev, transport by air from Chuguyev to Tashkent, and transport by motor vehicle from Tashkent to Tashkumyr. The ability to ship the turbine water wheels in one piece resulted in significant cost reductions and increases in product reliability and performance. Figures 2, table 1; reference 1 (Russian).

Designing an Orthotropic Spherical Shell With Two Openings

[Article by N.Kh. Noraliyev and K.I. Shnerenko, Mechanics Institute, Ukraine Academy of Sciences; UDC 539.3]

[Abstract] The elements of shell structures are frequently weakened by the presence of several openings. The mutual effect of stress concentrators in such structures may have a significant influence on their strength. In view of this fact, the authors of this study examined the mutual effect that two closely spaced non-reinforced openings in an orthotropic shell made of a composite material have on the concentration of stresses in the said shells. The study was conducted within the framework of a refined Timoshenko-type theory by using the finite elements method. A numerical algorithm and set of applications programs were developed to solve problems by the new method. Further calculations designed to determine the effect of the number of finite elements on the results of computation of the concentration of stresses in an orthotropic spherical shell with specified physical and geometric parameters established that it is sufficient to restrict the number of elements to 78. After analyzing the computation results, the authors concluded that the effect of the shear parameter on the stress concentration coefficient increases as the distance between the two openings in the shell decreases. Increases in the shear rigidity parameter were also found to result in an increase in the maximum values of the annular forces (by 8% in the specific case studied) and in the annular moments (by 28% in the case studied). The orthotropy of a shell's material has a significant effect on the distribution of stresses within the shell. The studies performed also confirmed the need to consider the factors studied when designing orthotropic shells with openings such as those studied because the said factors significantly alter the picture of the shells' stress-strained state. Figures 3, tables 3; references 7 (Russian).

Beam Systems That Are Adaptable to the Shape of the Object Being Heated

[Article by A.V. Arendarchuk, All-Union Scientific Research, Planning, Design, and Technological Institute of Electrothermal Equipment; UDC 535.2]

[Abstract] Thermal irradiation is currently one of the most promising technologies in a variety of areas of human activity ranging from heat treatment in machine building to heat therapies in medicine. The main direction in improving the said technology has been to develop new methods of converting and controlling propagation of the radiation. One area that is especially important is that of creating beam systems adaptable to the shape of the object of the thermal irradiation. The concept of adaptive irradiation is based on the concept of adaptation in the broad sense of the word, in accordance with which a limited number of controlled thermal radiation sources in the form of a beam system are used. These sources are controlled based on a three-dimensional mathematical model of the beam system and the object that is formed by means of input from sensors while the system is in operation. The main difference between such systems and adaptive optics systems is that adaptive optics is based on the classical theory of automatic control, where the accent is on the temporal aspect of the control process, whereas adaptive irradiation is based on the more general principles of adaptive robotics, where the emphasis is on the spatial aspect of the problem. This makes it much more difficult to describe the interaction of the irradiation system and the irradiated object and to organize the control process. The author of this article describes and diagrams an adaptive thermal irradiation system containing 1) a subsystem of directed thermal radiation sources; 2) a control and facility interface system; and 3) a subsystem to determine the shape of an irradiated object by using machine vision devices. The subsystem to determine the shape of the irradiated object is based on detection and ranging sensors that are used to take remote measurements of the shape of the object's surface or a portion thereof. Laser detection and ranging sensors are preferred. The control subsystem is based on a microprocessor or computer and is combined into a single unit with the subsystem for quick exchange of information between the system and its operator. The adaptation capabilities of the adaptable irradiation system are provided primarily at the algorithm and software level. The problems of mathematical modeling of the surfaces of complex three-dimensional forms and their movements is examined by way of the example of the observation of patients' body motions during the course of the irradiation process. Some of the mathematical problems arising during the course of developing algorithms and software to support such a system are discussed. Figure 1; references 9 (Russian).

A Study of the Distinctive Features of Heat and Mass Transfer in the System Gas-Solid at Low Temperatures

[Article by N.V. Atapina, D.N. Garipogly, A.S. Drobyshev, V.A. Kuzmin, and S.L. Maksimov, Kazakh State University imeni S.M. Kirov, Alma-Ata; UDC 542.8;620.191.5]

[Abstract] The authors of this study have described an experimental unit that may be used to study the distinctive features of heat and mass transfer at a gas-solid interface at temperatures ranging from 20 to 200 K in the wavelength range from 0.2 to 20.0 μ and under gas-phase

pressures ranging from 10^{-6} Pa to 10^5 Pa. The experimental unit is essentially a universal vacuum spectrophotometer with a continuous-type cryostat located in the center of its vacuum chamber. The unit also contains IPDO-2 and ROMS-2 mass spectrometers, an MDR-12 monochromator, an IKS-29 spectrometer, and an RTN-31G converter. When studies must be conducted at temperatures below 80 K, the cryostat is replaced by a microcryogenic machine with an operating temperature range up to 20 K and a working surface diameter of 80 mm. The procedure for using the new unit to conduct experiments and the methods used to measure and calculate spectral reflectivities, the condensation rate and thickness and density of the cryoprecipitate of a gas, and the refractivity of gas cryocondensate are all detailed. The new unit has been used to obtain data regarding the kinetic laws of the condensation of water vapors on a cooled base. These results, coupled with data regarding the dependence of the refractivity of the cryoprecipitate on the mode of precipitation, permitted the authors to conclude that the mechanism of the gas-solid phase transition has been altered in the region under examination. The studies further demonstrated that the formation of layers of cryocondensates results in a sharp change in the spectral reflective characteristics of both the absorbing and reflecting surfaces. Being able to give consideration to this effect provides a much more realistic (much less distorted) picture of actually occurring processes. Figures 4; references 11: 8 Russian, 3 Western.

Synopses From 'Mechanics of Composite Materials'

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[English abstracts of articles appearing in 'Mechanics of Composite Materials', Sep-Oct 91]

[Text]

UDC 678.019.38:678.01:539.612

Effect of Biochemical Treatment on the Strength and Adhesion of Poly-p-amidobenzimidazole Fibres. A. I. Sviridenok, T. K. Sirotina, E. V. Pisanova, and S. F. Zhandarov, pp 771-776

Changes in the strength of poly-p-amidobenzimidazole (PABI) fibres and their adhesion to polycarbonate (PC) and polysulphone (PSP) matrices are investigated after treating the fibres with Bacillus bacteria. A statistical analysis of untreated PABI fibres showed that the strength distribution was bimodal (Fig. 1a). A biochemical treatment shifted to the right one of the modes, which could be accounted for closing the surface flaws by creating a grafted copolymer layer on it. Another distribution mode unchanged with the treatment was associated with internal flaws. On the whole, modification of the PABI fibres with microorganisms increased the mean strength of single fibres and decreased the strength

scattering (Fig. 1, Table 1). Failure of the fibres changed likewise: fibrillation, which is characteristic of untreated fibres, was not observed for modified fibres (Fig. 2). The surface wetting of the fibres treated with molten polysulphone had improved. A method of three fibres was used to determine adhesion of untreated and modified fibres to polymer matrices. The mean bond strength of PC and PSP to modified fibres was almost twice as high as to untreated fibres. The adhesion contact of untreated fibres with the polymer failed due to interfacial shear, while surfaces of the modified fibres had features of a cohesive failure for both the matrix and single fibres (Fig. 4), which indicated of a diffuse fibre-matrix interphase formation.

UDC 541.64:539.3:534.8:678.01

Acoustic Study of the Deformation of Polymer Matrix in Hydrostatic Pressure. A. Ya. Goldman, G. E. Mesh, and V. S. Khanarin, pp 777-782

An original method has been developed for ultrasonic measurement of glassy styrene acrylonitrile and high density polyethylene copolymers deformed in a chamber of high pressure. The method used for determining the velocity of longitudinal and shear waves in the range of 1-5 MHz allowed to examine the mechanism of deforming the thermoplastic matrices. The stress-strain curve was found to have three different zones connected with the change in the ultrasonic velocity. At a pressure of 22 MPa the styrene acrylonitrile copolymer showed a brittle-ductile transition as a consequence of two competing processes—nucleation of defects and their termination due to the changes in local orientation. The analysis of the propagation of the longitudinal and shear waves suggested of a fluctuation in the free volume of the polymers in deformation.

UDC 621.375.826:678.01

Heating of Polymeric Coatings by Infra-Red Laser Irradiation. L. N. Nikitin, E. E. Said-Galiyev, and I. G. Merinov, pp 783-786

A model based on the Fourier equation of heat conductivity is given for calculating the temperature fields in laser irradiated coatings on substrates of high heat-transfer. The surplus stationary surface temperatures of unfilled and composite coatings based on poly-2,6-dimethyl-1,4-phenylenoxide have been calculated. During irradiation the substrate surface is kept at a room temperature. Thin polymer coatings with a thickness of a few tens of microns are shown to be able to protect such materials of laser optics as NaCl, KBr, CsI, copper and aluminium mirrors, etc. from oxygen, air moisture and mechanical damage. The thickness of the coating has been found whose surface can withstand 693 K, when the polymer starts decomposing. The calculations are applicable for most of the thermostable polymers of similar thermally physical characteristics. The proposed model

however, has certain limitations connected with the irradiation duration. For longer periods the heat problem needs adjustment.

UDC 669.018

Engineering Mechanics of Composites in the USSR. Yu. M. Tarnopolsky, pp 787-795

The mecnanics of composites as an independent offshoot of the mechanics of deformable media is in the stage of growth, development and formation. Its branches have been expanded to various extents, many problems are far from completion, yet the advances in engineering mechanics of composites are indisputable. The Soviet science also has made great contributions. The present review is based on the examples belonging to the scope of interests of the author and, naturally, does not claim to exhaust the theme.

UDC 539.3:678.067

Nonlinear Deformation and Strength of Stochastic Composites With Damaged Matrix. B. P. Maslov and S. N. Bugai, pp 796-803

A method is proposed for calculating the elasticity and strength of stochastic composites with a nonlinear matrix weakened by spheroid pores and penny-shaped cracks. Three-component composites which are reinforced with continuous anisotropic fibres and oriented randomly with short spheroidal fibres are considered. The obtained software programs are applied for automatic systems of designing structures from composites.

UDC 539.4:678.067

Model Notions of the Fracture of a Unidirectional Composite Material With Brittle Fibres in Tension. N. A. Makhutov and I. I. Koksharov, pp 804-811

The regularities of deformation and fracture processes for unidirectional composites with brittle fibres are investigated in tension. Advantages of the strain characteristics used instead of stresses are shown. High values of the strength characteristics and crack resistance of the composites are manifested in their capability of prolonging the strength by transferring the loads from fractured to the adjoining elements. Variation of the volume fraction allows to obtain materials with the properties expressed by the matrix, fibres or the composite, which are present not only in ultimate strains, but also at the level of microstructural damages during loading. The effect of initial defects on the critical strains and stresses has been determined from the numerical models.

UDC 539.43:678.067

Effect of Phase Lag on the Cyclic Durability of Laminated Composites. Ya. A. Andersons, V. A. Limonov, and V. P. Tamuzs, pp 812-822

The fatigue of laminated fibre reinforced composites in out-of-phase, biaxial cyclic loading were studied theoretically and experimentally. Tubular wound specimens of epoxy matrix and organic Kevlar type fibres were tested and the fatigue strength was investigated in two loading modes—a cyclic torsion was combined with axial tension or compression with phase lag $\psi = 0$, $\pi/2$, π. The durability was found to decrease with an increased phase shift both in axial tension ($R = 0.1$, Fig. 3-a) and compression ($R = 10$, Fig. 3-b).

The problem of predicting the fatigue in out-of-phase loading appeared to be more tractable for fibre reinforced composites than isotropic materials. Any complex loading of fibre reinforced composites leads to some sophisticated and yet obviously uniaxial stress variation in the fibre direction and to complex two-dimensional cyclic loading of shear and transverse stress in the matrix of each ply. A matrix failure criterion (Eq. 2) has been proposed for a unidirectionally reinforced ply, and the ply discount method has been modified to account for the phase lag. The calculated S-N curves agreed reasonably well with the experimental data (Fig. 3).

UDC 629.12:681.3.06

Dynamic Analysis of Damping Coatings by Finite Element Method. R. B. Rikards and E. N. Barkanov, pp 823-830

The need to improve the damping characteristics of structures has facilitated the use of damping coatings comprised of one or two layers. A layer adjacent directly to the structure is made from a material with high dissipative characteristics, while the other has a high modulus of elasticity. The latter is used to increase shear deformation in the damping layer and thereby to raise efficiency of the coating. To simplify the technology, however, the constraining layer may be absent. The main object of the paper is calculation of the damping characteristics of the coatings in harmonic oscillations at frequencies close to natural vibrations of the structures. The methods of complex eigenvalues and the potential energy of eigenmodes allowed to define the damping values of laminated structures from the given data on the damping layer. The finite element method in the form of a displacement method is the research method applied here. Finite element models of "sandwich" type, with each layer treated as a Timoshenko beam and with allowance for a displacement continuity between the layers, were used for analyzing laminated beams with soft layers. A complex theory of interior friction was also applied. Examples of the calculations are given and compared with the earlier results of more restricted theories.

UDC 539.3+534.1

Load-Carrying Capacity of Composite Panels in Axial Compression. N. S. Azikov, pp 831-838

Since the conventional engineering method used for strength analysis of metal panels in axial postbuckling compression cannot be applied to composite structures, a method is suggested for determining the postbuckling behaviour of a rectangular composite panel in uniaxial compression. The postbuckling of rectangular unsupported plates in axial compression has been investigated in the previous work [2] by one-term approximation of the deflection to an unknown amplitude and wave numbers. The relationships obtained from solving the von Karman equations of large deflections were used for the composite panel having elastic ribs. In order to obtain displacements, strains and membrane forces, the boundary conditions were expressed in terms of plate strains. Substituting the displacements, strains, membrane forces and bending moments by the energy functional and minimizing the latter with respect to amplitude, a resulting equation was obtained for the deflection amplitude. The wave numbers were determined by comparing the values of the potential energy, since an equal energy produced a stable form of equilibrium. A load critical for the panel was found from Eq. (6). The load-carrying capacity was judged from the strains and stresses acting in the plate layers, and using the strength criterion. The ultimate load was determined with the iteration procedure. The numerical results are given for a carbon-epoxy panel with ribs made from the same material. The relationships between the orientation angles of plate layers and the critical loads for panels are shown in Figs. 2 and 3, while Fig. 4 gives the relationship between ultimate loads for panels and various types of reinforcement. Analysis of the critical and ultimate loads shows the influence of stiffened ribs on the buckling and postbuckling behaviour of the panels. The distribution of longitudinal membrane forces is given in Fig. 5. The strength coefficients are grouped in Table.

UDC 678.067:539.4.001

Critical Equilibrium of Transversely Isotropic Bodies With a Circular Internal Crack in the Plane of Istropy in Short-Term Tension and Recurrent Loading. G. P. Zaitsev, pp 839-844

The critical equilibrium of transversely isotropic bodies with a circular internal crack in the plane in isotropy has been examined in uniaxial static and cyclic tension along the direction normal to the plane of isotropy. The critical stress formulas are derived from the application of the energy (1), force (6) and generalized energy methods (23). All the final expressions have been based on using the same parameters, such as the strength of a nondefective material and the critical crack radius. The maximum critical stress was determined by the energy method, while the generalized energy method produced the minimum critical stress. With the crack radius equalling 20 critical radii (7), all the expressions gave practically identical critical stress values (Fig. 3). Equation (22) of the critical stress based on the generalized energy method, just as the numerical Rungue-Coutt method, were used for calculating the cycle numbers up to the

moment of failure (Fig. 3, curves 4, 5, 6). The fatigue curve of the examined material is given in Fig. 4.

UDC 539.3

Plane Problem of the Stability of Composites With Sliding Layers. I. A. Guz, pp 845-850

The structure loss of stability is considered for a composite with sliding layers under compression by "dead" loads along layers. A characteristics determinant was obtained for the plane problem of three-dimensional linearized theory on the stability of deformed bodies in the case of the second variant of the theory of small precritical strains. The critical strains were calculated for the cases of rigid-contacting and sliding layers, which were modelled by a compressible elastic isotropic body and an incompressible elastic plastic isotropic body with power-mode dependence between the intensities of stresses and strains.

UDC 62.562+621.8-03:678.067

Dynamic Behaviour Analysis of an Energy Accumulation System Comprising a Composite Flywheel. 2. The Effect of Internal Friction of a Flywheel on the Rotation Stability. G. G. Portnov, P. A. Moorlat, and I. N. Barinov, pp 851-860

A simple system for energy accumulation comprises a rim and a massive shaft with elastic damping couplings, whereas the shaft runs in elastic damping bearings. A parametric analysis is made of the stability limit of the system during rotation. It is shown that the instability of vibrations during rotation of the flywheel having internal friction can be avoided by damping effected by supports provided that their stiffness is much lower than that of the flywheel. Flywheel designs with high structural damping and, consequently, unsuitable for supercritical conditions are described.

UDC 539.3

A Three-Dimensional Numerical Analysis of Free Vibrations of Laminated Anisotropic Shells of Revolution. P. Ya. Nosatenko and M. N. Omelchenko, pp 861-868

An algorithm for calculating the natural frequencies and vibration modes of composite shells of revolution has been developed on the basis of finite element idealization of a three-dimensional heterogeneous anisotropic continuum. The influence of anisotropy on the dynamic characteristics of a cross-ply double-curved shell are investigated. The vibratory laminated anisotropic shell is shown to have a complex stress-strain state, whereas the effects of transverse strain components cannot be ignored. Calculations based on an orthotropic model, however, lead to an increase of the natural frequencies and give incorrect data on the lowest modes of vibrations.

UDC 539.4.011:678.5.029.46

An Applied Model for a Composite With Short Lengths
Reinforcement and Incomplete Bonding. Ya. A. Brauns
and K. A. Rocens, pp 869-875

An approximate method was proposed for estimating the
elastic characteristics of a high-filled plastic containing
flat wood particles of certain orientation. In the model of
material each reinforcement direction was a unidirec-
tionally reinforced calculated element, while the binder
volume in reinforcement directions was assumed to be
proportional to the filler volume. The calculations were
performed in several steps. Firstly, the effective values of
elastic characteristics of wood particles were determined
taking into account compression in fabricating wood
chip boards, and considering incomplete bonding
between the particles and their statistical length distri-
bution. Secondly, elastic characteristics of the calculated
element with allowance of anisotropy of the particles was
defined by the method of sections. And finally, the
elastic characteristics of spatially reinforced composite
were determined by averaging the tensor components of
stiffness and comphance [as published] of the calculated
element. The theoretically predicted technical character-
istics of the composite were compared with the experi-
mental data obtained from testing the specimens of
wood particle boards.

UDC 539.377:678.067

Analysis of Multidimensional Domain Shape of Opti-
mized Composite Characteristics. A. F. Kregers and M.
F. Rektinsh, pp 876-884

A problem of multipurpose optimization of five charac-
teristics of composite materials, three moduli of rigidity
and two coefficients of linear thermal expansion, is
solved on the example of a laminated composite having
three directions of reinforcement and two controlled
parameters. Emphasis is placed on the method of deter-
mining the coordinates of boundary points that define
the five-dimensional domain of compatible characteris-
tics of the composite material, and projecting the
domain Y in the given plane and revealing the function-
ally efficient boundaries with simultaneous analysis of
three characteristics. Projections and cross-sections of
the domain Y give more qualitative and evident data
than the isolines of the characteristics plotted in the
plane of the controlled parameters.

UDC 539.3

Isoparametric Finite Element of Composite Shell With
Double Approximation of Strains. A. I. Golovanov and
I. Yu. Krasnovsky, pp 885-890

A new variant of the finite element of a multilayer
composite shell of an arbitrary shape is constructed on
the basis of equations of the theory of elasticity and the
hypothesis of rectilinearity of normal elements. Biqua-
dratic approximation of the displacement and the

method of double approximation of the strains
according to their values at the points of minimal error
are used. For a more precise determination of tangential
stresses and ensurement of their continuity in thickness,
the stresses are calculated from the equations of equilib-
rium in each layer.

UDC 539.216.1:536.2:678.067

Heat Conductivity in Multilayered Carbon Fibre Rein-
forced Plastics. O. M. Gaker, I. V. Goncharov, V. L.
Mikov, and A. V. Sukhanov, pp 891-897

The heat conductivity of composite laminates has been
studied experimentally and theoretically. The multilay-
ered composite materials were made by pressing
prestacked layers of LU-P carbon tape and ENFB binder
based prepregs. The carbon fibre reinforced plastics
(CFRP) had five types of layer arrangements: [0], [0/90],
[0/+/- 45], [0/+/-45/90], [0/+/- 30/+/- 60/90]. The exper-
imental data for a unidirectional composite were used to
obtain calculation formulas for analyzing the heat con-
ductivity of CFRP having various patterns of monolay-
ers. An analytical equation was derived for correcting the
experimental errors arising from the cylindrical shape of
specimens. A multitemperature model of heat propaga-
tion in layered media has been formulated, which sim-
plifies greatly the initial system of equations for heat
conductivity and considers better the peculiarities of the
studied structure. The model considers the heat expan-
sion in a two-layer infinite composite along the straight
line $Z = 0$. The advantages of the multitemperature
method are shown. The formulas have been obtained for
calculating a temperature gradient between the layers
differing in their nondiagonal components of heat con-
ductivity tensor. The final expressions establish a rela-
tionship between the locations of temperature gradient
maximums in layers, and the angle of the layer and its
coefficient of anisotropy.

UDC 539.2:539.4:678.067

Fabrication of Composites by Internal Crystallization. S.
T. Mileiko and V. K. Kazmin, pp 898-908

A new method of producing fibrous composites is sug-
gested which is based on impregnating prefabricated
cylindrical pores of the matrix with fibrous melt and
subsequent crystallization of the melt. The possible
crystallization process is qualitatively described, the
experimental data on sapphire fibres—molybdenum
matrix composite illustrate the fabrication method. The
fabrication conditions of obtaining single crystalline
fibres are given. The failure mechanism of the composite
and fibres is also studied. The defects determining the
strength of fibres are shown to be distributed within the
fibre volume.

UDC 539.3:628.02

An Evolution Form of Physical Relationships in Technological Problems of the Mechanics of Composite Materials. V. T. Tomashevsky and V. S. Yakovlev, pp 909-917

On the basis of laws of chemical kinetics and general origins of thermodynamics are determined the physical relationships for a polymer matrix taking into account an evolution of its thermally physical and mechanical properties in the technological processing of polymer composite materials into structures. The evolution model of the polymer matrix state comprises a system of equations for chemical kinetics, thermal conductivity and constraint equations for the components of stress and strain tensor, which are the same for the whole technological cycle. The exponential dependence of the properties of curable polymer matrix on the conversion degree has been revealed. Contrary to traditional treatment now the physical contants [as published] have to be known merely for the thermodynamic equilibrium states—activation, structurization and stabilization.

UDC 621.03:678.2

Radiation-Acoustic Effect in Polymers Irradiated by Strong Electron Beams. G. I. Gering, N. A. Eliseev, and V. V. Fedosov, pp 918-923

The mechanisms of generating mechanical stresses in polymers (polyethylene, polycarbonate, polytetrafluoroethylene, epoxy resins, polymethylmethacrylate) were experimentally studied by electron irradiation. The viscoelastic parameters of the investigated polymers have been determined, and the dynamic mechanical stresses arising and propagating in the viscoelastic material have been calculated.

UDC 539.4:678.067

Behaviour of Carbon/Plastic Composites in Uniaxial Loading. M. M. Stevanovich and T. B. Stecenko, pp 924-927

In mechanical testing of unidirectional composites based on different carbon fibres and epoxy or polyester resins, the macromechanical properties (tensile, compressive, shear, impact) have been determined. By microfractographic observations the failure surfaces and characteristic features of fracture have been studied. The results were analyzed by comparing experimental and calculated values, different and the same characteristics of one or several types of composites, respectively. Disagreement of the experimental and calculated values of tensile and compressive moduli are explained by a decrease of compressive and an increase of tensile modulus with the strain growth. In carbon/epoxy composites the calculated and experimental values of tensile strength coincided, while compression strength was 75 percent of the calculated value. In carbon/polyester composites the tensile and compression strength were 80

and 25 percent of the theoretical value, respectively. An impact fracture energy determined by Charpy pendulum of composites with polyester matrix was twice of that determined for composites with epoxy resin. All the established facts were correlated with consideration of the interlaminar shear strength (fibre-matrix bond strength) values of composites based on epoxy and polyester resin, and keeping in mind the conclusions of the performed failure analysis. Due to low fibre-matrix strength in tension of specimens with polyester matrix, the numerous decohesions, preceding fibres breakage, come as the reason of premature splintering failure. In similar failure mechanisms, but of increased intensity, the reason of low compression strength of composite E has still to be revealed. The numerous splittings taking place during impact of this composite increased highly the impact fracture energy.

UDC 620.178:678.067

Fatigue Resistance of Carbon Material in Symmetric Tension-Compression. R. P. Apinis, M. Ya, Mikelsons, and V. I. Khonichev, pp 928-930

The results of fatigue testing of carbon-carbon composite materials in symmetric tension-compression are presented. The loading was carried out at two frequencies, 6 and 330 Hz. The fatigue resistance of the material is shown to be independent of the frequency of the given loading conditions and can be described by a uniform fatigue curve. It has been also determined that the tested material had a larger relative index of the fatigue resistance than steel, fibreglass and organic reinforced plastics.

UDC 678.742.2.027.98:539.3

A Generalized Description of the Deformation Properties of Oriented Crystallized Polyethylene. Yu. M. Boiko, V. V. Kovriga, and A. Ya. Gol'dman, pp 930-935

The stress-strain curves of oriented crystallized polyethylene have been studied in a wide range of temperatures, strain rates and drawing ratios. All the variety of stress-strain curves is tried to be described by a single generalized stress-strain curve obtained by normalizing the initial stress-strain curves in terms of the stresses and strains at specific points of these curves.

UDC 539.4:678.067

Homogeneous Models for Some Types of Spatially Reinforced Composites. O. V. Tatarnikov, pp 935-939

The choice of homogeneous models is considered for composites spatially reinforced with carbon filaments. On the basis of assumed types of elastic symmetry of the matrix and reinforcement, a complete set of elastic characteristics of the components necessary for constructing a homogeneous model is given. A concept of indefiniteness of elastic characteristics in the represented volume is introduced, which is related to the error of

transition from a heterogeneous medium to a homogeneous model. The stress-strain state of cylindrical structures made of composites with 3D and 4D reinforcement arrangements (Fig. 1) and subjected to thermal and applied loading was calculated by the method of finite elements. The elastic characteristics of composites were defined by the energy averaging method (Fig. 2). Two types of cylindrical structures, one in nonuniform temperature field and the other subjected to inner pressure, were compared.

UDC 532.5:532.135

Effect of Molecular Composition of Thermotropic Copolyester on the Viscoelasticity of Its Melt. L. A. Faitelson, E. E. Yakobson, V. G. Kulichikhin, and O. V. Vasilyeva, pp 939-943

The frequency dependences of complex dynamic shear modulus components $G'(\omega)$ and $G''(\omega)$ were investigated for thermotropic copolyester composed of 60 mol. % p-hydroxybenzoic acid and 40 mol. % polyethylene terephtalate melts. The measurements were performed on Weissenberg rheogoniometer R-18 in a range of frequencies $0.158 \leq \omega \leq 62.8. s^{-1}$ at the temperatures of 260, 275 and 295°C. It was found that the value of G'' decreased with the temperature growth, while the frequency dependences of $G'(\omega)$ at 275 and 295°C practically coincided, and the method of reduced variables was not applicable. It has been presumed that for copolyesters consisting of rigid and flexible polymer blocks, and the amount of the former being lower than 70 mol. %, no stable liquid-crystalline phase would set in to form a matrix of the composite copolymer melt.

UDC 532.5:532.135

Temperature-Time Reduction of the Viscoelastic Properties of Thermotropic Polymers in Liquid-Crystalline State. E. E. Yakobson, L. A. Faitelson, and V. G. Kulichikhin, pp 943-945

The frequency dependence of complex dynamic shear modulus components $G'(\omega)$ and $G''(\omega)$ for thermotropic copolyester composed of 30 mol. % polyethylene terephthalate/70 mol. % p-hydroxybenzoic acid melts were investigated in a temperature range $T = 210...270$°C. The possibility of constructing composite curves $G'b_T$ vs. ωa_T and $G''b_T$ vs. ωa_T has been shown, where the factors a_T and b_T are temperature-dependent only. The copolyester melt was found to be a thermorheologically complex medium, which at temperature lower than 260°C would have a liquid-crystalline phase containing unmelted p-hydroxybenzoic acid crystallites. In transition from a two-phase state to a liquid-crystalline phase the function $a_t = a_T(T)$ changed its sign.

Eighth International Conference on Mechanics of Composite Materials, p 958

April 1993, Riga, Latvia
Latvian Academy of Sciences
Institute of Polymer Mechanics

First announcement and call for papers

Scope and Main Topics

Regular conferences on the mechanics of composite materials are traditionally organized by the Institute of Polymer Mechanics of the Latvian Academy of Sciences and are held in Riga. The conferences have always become a forum of the leading experts of the whole Soviet Union specializing in the mechanics of composites and have helped coordinate the scientific investigations undertaken in this vast region.

The purpose of the eighth conference is to widen the exchange of scientific achievements gained in the Soviet Union and Western countries and to facilitate the expansion of contacts among individuals and collectives.

The conference intends to discuss the following major subject areas:

- Properties of (Polymer, Metallic, Ceramic) Matrices;
- Properties of Fillers and Reinforcing Fibres;
- Role of Interface;
- Theory of Reinforcement and Deformation of Composites;
- Strength, Fatigue and Failure of Composites;
- Optimal Design of Structures;
- Prediction of Creep Deformation and Long-Term Strength of Polymer and Composites, Effects of Environment;
- Nondestructive Testing Techniques;
- Mechanical Aspects of the Technology of Creating Composite Structures;
- Rheology of Polymer Melts.

Paper Demands and Deadlines

Manuscripts of the papers meeting the requirements of the journal (MKM, 1991, No 2, p. 368...369) are invited to be submitted at your earliest convenience, yet not later than November 1, 1992. The official languages of the conferences will be English and Russian.

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Induction Motor Control Circuit Providing "Crawl" Speeds

927F0159A Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 11, Nov 91 pp 8-9

[Article by A.I. Tanatar and V.A. Uzhelovskiy, candidates of technical sciences; UDC 621.313.3:62-5]

[Abstract] Brief periods of reduced motor rotation speeds ("crawl" speeds) are often required in many situations. Crawl speeds are generally achieved by creating an asymmetry of the voltages in the motor's stator by means of autotransformers, potentiometers, or resistors connected to one of the stator's phases. The authors of this article describe a new system in which crawl speeds are achieved by connecting the motor's stator to a network with one "inverted" phase while the other phase is connected to a zero drive. Calculations have shown that the starting moment of the new system is between 0.25 and 0.3 and the the motor's idle slip is between 0.4 and 0.6. Consequently, during operation with an "inverted" phase, the motor may operate with a rotation speed that is 20 to 40% of its rated rotation speed. The energy losses in the motor will be about 2.2 times higher than the rated energy loss, and the motor will not be significantly affected by brief periods of operation at the reduced rotation speed. The cost of the additional equipment (one reversing and one nonreversing magnetic starter, time relays, and diodes) is between 30 and 40 rubles. A circuit diagram is provided. Figure 1.

Vortex Cooler for Electronic Control Circuits

927F0159B Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 11, Nov 91 pp 10-11

[Article by I.M. Breyev, candidate of physical and mathematical sciences; UDC 621.9:529.003.13]

[Abstract] The introduction of automated lines is one of the main directions in the development of modern machine building. The efficiency of such lines is largely dictated by the reliability of the NC machines and other robotic equipment of which they are composed. According to the domestic literature, 90% of the failures of the electronic equipment used on automated production lines are related to overheating of the electronic components. In view of the importance of the problem of adequate cooling of the said electronic components, a research study was conducted to develop a new method and device to cool electronic equipment by using air. Experiments examining the use of vortex air coolers to stabilize the operation of the electronic control units of imported robotic equipment were conducted at the Leningrad Phonograph Record Plant. A VVP-20/1 vortex cooler was installed on a line of presses and connected to the shop's pneumatic system. The pneumatic system in question has a working pressure of 0.6 MPa and three lines to tap the cold flow, which made it possible to immediately spread the cold flow from one vortex device to the three cabinets of the electronic control system controlling three AD-1207 automatic presses. The studies performed demonstrated that as the pressure of the compressed air increased, the cold productivity of the vortex device and the temperature effect of cooling both increased. The consumption of compressed air and (consequently) the cost of the vortex device per unit time and its operating costs increased at the same time, however. In the four months of the test, the vortex cooler operated for 1,000 hours, during which time it serviced three automatic presses. Not one case of downtime owing to heat-related failures of the microelectronic components in any of the automatic presses was recorded during that time. When this failure rate was compared with that of any other three automatic presses that were not serviced by the vortex cooler, it was discovered that using the vortex cooler resulted in an extra 4,000 rubles worth of production. The operating costs for the cooler totaled 259 rubles. Thus, the savings resulting from using a type VVP-20/1 vortex cooler on an entire automatic line consisting of 23 automatic presses was estimated at 30,000 rubles. It was further determined that compressed air that is to be used to cool electronic components must be especially free from moisture and oil. It was therefore recommended that the pneumatic systems of shops with a vortex cooler be equipped with standard moisture and oil separators such as those manufactured by the Pnevmoavtomatika Scientific Production Association in Simferepol. Figure 1, table 1.

Selecting the Structure of High-Productivity Automated Lines

927F0159C Moscow MEKHANIZATSIYA I AVTOMATIZATSIYA PROIZVODSTVA in Russian No 11, Nov 91 pp 20-24

[Article by V.P. Zenchenko, doctor of technical sciences, and N.Ye. Shamaydenko, candidate of technical sciences; UDC 621.9.06-52:658.527]

[Abstract] When a manufacturing process is automated, the need to increase productivity makes it necessary to differentiate the manufacturing process into individual operations performed at single-position automatic machines that each perform a primary operation and those related operations that it can given its design. In this manner, a technological chain is formed that consists of single-position automatic machines. Beginning at some specified point, further differentiation of the manufacturing process becomes ineffective and infeasible from the standpoint of increasing productivity. For this reason, in their examination of the problem of selecting the structure of high-productivity automated lines, the authors of this article operate under the assumption that the manufacturing process has already been specified and differentiated with respect to some optimality criteria and that any changes in the differentiation stage cannot result in an increase in the overall productivity of the automated line. After this point has been reached, the process of developing an automated line entails

introducing branched flows and making provisions for the lengthiest operations to be performed on automatic machines operating in parallel with one another. Automated rotary lines have become a popular choice of designers of high-productivity automated processes because combining machining with the rotation of the rotor greatly simplifies loading and unloading operations. Rotary lines also have a number of shortcomings that restrict the areas in which they may be used. For example, the problems associated with feeding rotary lines and transferring products from operation to operation have only been fully resolved for products in the shape of bodies of revolution and products that do not require orientation. Only products whose dimensions are less than the diametral dimensions of the rotors may be machined on rotary lines. Problems also arise in the areas of chip removal and feeding lines whose rotors are in continuous motion. One automated rotary line configuration that has been proposed to remedy many of the problems that have been encountered is a scheme consisting of a conventional rotor having eight single-position automatic machines, a rotor loading zone, a live zone, a rotor unloading zone, and an "off-cycle" zone. After the feasibility of each section of such a line has been determined, the operation of a multiple-section line may be planned. Individual sections' operating cycles are subdivided into additional cycles, and the cycles of the various sections are coordinated. The authors of this article have illustrated this design process by way of the example of a line to press products from some powder. The pros and cons of the automated rotary line principle are compared with those arising in the case of an automated line distributed conveyer (such lines are much more flexible than rotary lines) and lines based on standard mechanical nodes, a linear conveyer, and standard manipulators. They describe an automated line for which prototype automatic presses with a working force of 1 MN have been manufactured by the Gidropress Association in Orenburg. Every four such presses is serviced by a single hydraulic unit. Each automatic press with a working force of 1 MN weighs 1,000 kg, and an eight-module unit of the said presses weighs 10,000 kg. A rotary automatic press with eight pressing positions working at the same pace (2 s) and with the same working force would weigh 35,000 kg (the extra weight is the result of the need to turn comparatively heavy pressing positions solely to simplify loading and unloading). Figures 4.

Selecting Motor Speed of Anthropomorphic Industrial Robot

[Article by M.G. Nikolayeva, Leningrad Institute of Precision Mechanics and Optics; UDC 62-83]

[Abstract] The problem of selecting the motor type for industrial robots (PR) in general and the motor speed of industrial robots with anthropomorphic structure in particular is addressed; in the latter case, the electric motor selection is guided by the consideration of not only minimizing the transient response time but also the robot mass. A formula is derived for calculating the anthropomorphic industrial robot transient response. A comparison of the theoretical response time to the time measured in an experiment demonstrates that the discrepancy does not exceed 10%, making it possible to conclude that the proposed formula may be used for analyzing industrial robots with electric drives using stepping motors with a sufficient degree of accuracy. Figures 2; tables 2; references 3.

Determining the Characteristics of a Stress-Strained State for Cracks in the Zone of a Butt-Welded Joint

[Article by N.A. Makhutov, I.I. Koksharov, and A.N. Tsyplyuk, Moscow and Krasnoyarsk]

[Abstract] The authors of this study worked to develop a method of determining the characteristics of the stress-strained state of cracks in the zone of a butt-welded joint. Specifically, they worked to determine the values of the stress intensity coefficients and J-integral of the said cracks based on the solution of a plane elastoplastic problem (i.e., the case of nonlinear elasticity) by means of the finite elements method. The calculations were performed for the case of the butt weld of the field joint of a vertical reservoir with displacement of the edges, with different locations of the crack (along the edge of the heat-affected zone, in the center, along the edge to the root), and with specified elastoplastic deformation characteristics in the different zones of the joint. For each of the problems, a test example (i.e., a known elastic solution) was used to perform a one-by-one trial of the net parameters and computation scheme in order to achieve an acceptable precision. The results of the numerical experiment were processed by the least squares method, and functional dependences for correction functions for a butt-welded joint with a crack were derived in the form of a power series. The studies performed revealed that displacement of the edges of the metal sheets of a butt weld results in a sharp increase in the stress concentration coefficients and characteristics of the stress-strained state at the apex of a crack during elastic and elastoplastic deformation. The functional dependences obtained may be used to calculate the strength of a butt-welded joint subjected to elastoplastic deformations, estimate the moment of onset of the limiting condition with respect to fracture mechanics criteria, and estimate the plastic properties of a material without having to conduct any special crack resistance tests. Figures 6, tables 3; references 6: 5 Russian, 1 Western.

The Stress-Strained State of Steam Pressure Piping With Expansion Bellows

[Article by M.Ye. Babeshko, A.Z. Galishin, V.I. Gololobov, V.B. Kovbasenko, V.A. Kovmunenko, G.V. Melakh, V.A. Marzlyakov, and Yu.N. Shevchenko, Kiev; UDC 539.374]

[Abstract] The authors of this study examined the stress-strained state of steam pressure piping with expansion bellows when the pipes were subjected to the effects of force and thermal loads. The thermoelastoplastic state of the bellows under the effect of an axial compressive force and during processes of unsteady loading and heating was examined. Because performing calculations involving expansion bellows with a large number (several dozen) of corrugations is problematic in any case and is especially difficult when the material of the bellows is subjected to high load levels causing it to enter a plastic state, the researchers confined their calculations to the case of one half-corrugation under the assumption that all of the corrugations would behave identically. The researchers verified the validity of their computation method by conducting a series of simple tension tests on cylindrical specimens at different fixed temperatures and loading rates that would not significantly affect the material's tension diagram. Two types of expansion bellows were examined. The first type were made of pipes of 20K steel and had a diameter of 89 mm. The second type were made of 12Cr1MoV steel and were 114 mm in diameter. Next, the researchers also studied the axisymmetric stress-strained state of the second type of bellows under loading conditions simulating a steam pressure pipe's transition from a steady state with subsequent cooling to its initial temperature and depressurization. Calculations were also performed for the case of elastic loading. Analysis of the deformation trajectories plotted at characteristic points of the shell demonstrated that using the theory of simple loading processes makes it possible to describe the deformation process with adequate precision. Finally, the researchers turned their attention to the problem of expansion bellows subjected to flexural strains such as those arising when steam pressure piping is transported while being supported at several points along its length. All of the calculated data were found to be in satisfactory agreement with the results of the strain measurements made during bench tests. As a result of their computations, the researchers were able to select a matrix form that makes it possible to produce expansion bellows that have the strength and rigidity required for various operating modes and for transport. The computation method developed was deemed suitable for estimating the stress-strained state of steam pressure piping with expansion bellows. Figures 5; references 5 (Russian).

Determination of the Life of Wheelpair Belts With Consideration for Gradual and Sudden Failures

[Article by A.V. Gorskiy and A.A. Vorobyev, Moscow; UDC 629.423.004.07]

[Abstract] Estimates indicate that if wheelpair bands continue to be replaced at their current rate, the need for new bands will increase by 65-70%. Because the production capacities of metallurgical machine building enterprises cannot meet this increased demand, a way must be found to increase the useful life of wheelpair bands. In view of this problem, the authors of this study examined a method of determining the life of electric locomotives' wheelpair belts with consideration for gradual wear-induced failures and sudden failures. By using censored mean-time-to-failure samples of the stream of wheelpair belt failures experienced in VL80S electric locomotives at the Georgiy-Dezh depot of the South-Eastern Railroad, the authors illustrate a way of determining the life of locomotive wheelpair belts. They model the occurrence of wheelpair belt failures in the formation of the superimposition of two processes, namely, sudden failures and the accumulation of damage (i.e., a model involving relaxation). In accordance with the said model, a wheelpair belt may be in one of two states that are arbitrarily placed in correspondence with two planes: S_0, i.e., fit for use, and S_1, i.e., unfit for use. The intensity of sudden belt failures given a fixed amount of wear is shown to be constant but to increase proportionally to an increase in the number of single instances of damage (i.e., in proportion to the amount of wear accumulated). The authors summarize the probability that a belt will move from a state of serviceability to a state of unserviceability within a small time interval in table form and represent the process of wheelpair belt failure in the form of a Markovian process. Next, a series of equations is derived for use in determining the probability of both sudden and gradual failure. Further calculations are performed to confirm that the model of failures with consideration for relaxation is adequate for computing wheelpair belt reliability indicators. As an objective function, the authors chose the total specific costs of making scheduled and unscheduled repairs. According to computations made by using their proposed method, the optimal time for which locomotive wheelpair belts should be used before being replaced is 560,000 km. A design life of 560,000 km will, according to the authors, result in the least expenditures for scheduled and unscheduled wheelpair repairs involving replacement of belts due to limiting wear or sudden failure due to weakening on the wheel tread. Figures 4, table 1; references 3 (Russian).

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